Designing Arcade Computer Game Graphics

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Dedication

This book is dedicated to my friends Dina Willensky, Stephanie Worley, Jennifer Higbee, Faye Horwitz, Sonya Donaldson, Karen Wasserman, and Howard Offenhutter, and to my parents, Dr. Bernard Feldman and Gail Feldman. These people stood by me during this project, always offering me encouragement and support when I needed it most. Thanks everyone!

I would also like to dedicate this book to my eclectic CD collection, for without the soothing sounds from the likes of Lush, Ride, The Clash, The English Beat, and The Creation this book would have never been completed.

Contents

Foreword

I have always looked at game artwork from a programmer's point of view. To me, the game artist was someone you worked around—someone necessary and important, but someone who would give you any old thing that looked good to him and it was up to the programmer to find a way to make it fit into the game. To this end, I have written books and Web pages on the importance of creating utilities to correct problems introduced by the artist: palette reduction, color matching, transparency replacement, size adjustments, and so on. It wasn't that the artist was incapable of taking control of those issues, or even that the artist had no understanding of the technical issues of game development; the problem was more a matter of communication between the programmer and the artist. The programmer would have a requirement and express it to the artist in technical terms. The artist's eyes would gloss over; he would nod and smile, and then pick up his mouse, and do his best to put out a product matching his understanding of the programmer's needs. Often this resulted in beautiful and enjoyable games. But behind the scenes there would be much frustration, as the programmer tried to explain and re-explain the technical aspects of game development, and the artist would try to explain and re-explain the limits of his tools and training.

That scenario has changed in recent years. With the advent of high-color and true-color display resolutions, the problems of palettes and color reduction have faded away. Modern tools give artists the ability to shrink or expand artwork, change the color depth, and add all the subtle nuances that make a game beautiful. And the systems modern game players use allow for greater resources to be expended, which means games can be bigger and use more memory, and artists are freed from the optimization constraints of earlier years.

But there is still the problem of technical communication between the programmer and the artist. It is not enough that an artist be artistically talented. He needs to be technically astute enough to be able to communicate in the language of the programmer. Once the programmer and the artist can communicate in the same language, many of the problems and frustrations of the past will fade away.

In this book Ari Feldman gently but firmly exposes the artist to the technical requirements and jargon used by professionals in the game development field. Rather than assuming the programmer is the only one who needs to know this stuff, Ari insists the artist take responsibility too. As a programmer, I think this is an idea for which the time has come. I have seen talented young artists drop out of the field of game development simply because they were overwhelmed by the expectations of the industry. And really, the technology behind computer artwork is not that difficult. All you really need is a resource that explains the capabilities and limitations to you. I believe Ari has provided such a resource with this book.

Ari is a long-time member of the game development community, and his *SpriteLib* collection has been popular for years. Recently, I was pleased to co-sponsor a game development contest with GameDev.Net (`http://www.gamedev.net`), in which programmers were asked to write games based on the artwork in *SpriteLib*. I was amazed at the results we got. There were more than two dozen entries, in categories ranging from a simple table tennis game, to various space shooters, to elaborate side scrolling adventure games. There were falling-bricks games, traffic control games, and fighting games. I couldn't believe how many ways the same artwork could be reused to produce such a vast array of delightful games.

So I guess all this proves that if artwork is well designed, you can do many things with it. And Ari is an expert on how to design arcade game artwork. So if you are interested in breaking into computer game development as an artist, it pays to study the wisdom of the masters, and this book is a great place to start. Good luck with your game development career!

Diana Gruber

Acknowledgments

I would like to give my special thanks to Jim Hill for the opportunity, Wes Beckwith for the patience, Kellie Henderson and Beth Kohler for their fine editing, and the entire Wordware Publishing staff for their help in putting this book together. Without the hard work of these folks, this book would have never been possible.

I would also like to thank Diana Gruber for writing a wonderful foreword and both Karl Maritaud and Neil Shepard for sharing their insights with me on the subject of creating arcade game graphics.

Introduction

Why This Book?

Arcade games have been captivating game playing audiences of all ages for well over twenty-five years now. Their popularity practically built a multi-billion dollar industry and their colorful characters and terminology have become permanent fixtures in our everyday language and cultural landscape.

Over the years, arcade game development has become big business, attracting an extremely large and loyal following among programmers. To address that community's interest in the subject, scores of books and hundreds of magazine articles have been written on the subjects of arcade game programming and design. Yet, inexplicably, next to nothing has appeared about a topic that is just as crucial to the successful implementation of an arcade game: graphics.

Simply put, without good graphics, an arcade game has no soul. Graphics play a central role in how people perceive and enjoy the arcade game experience. Just imagine how boring a game like *Sonic the Hedgehog* would be if the adorable Sonic was represented on-screen by blocky ASCII characters rather than a dynamic, blue hedgehog graphic. Or, consider how much fun *Mortal Kombat* would be if characters like Sub-Zero appeared as lifeless stick figures rather than as photo-realistic combatants. If arcade game graphics did indeed look like the ones in these examples, arcade games wouldn't hold anyone's interest for very long, would they?

For far too long, the process of designing and creating the graphics for arcade-style games has been ignored. Quality graphics are as essential to an arcade game's development as solid design, addictive game play, and clever programming. And that is exactly why I wrote this book. If you are interested in learning how graphics are designed, created, and implemented in arcade games, then read on.

You are probably wondering why I even bothered to write a book on a "dated" topic such as 2D arcade game graphics design when 3D-style games are all the rage, right? Well, actually there are a number of very good reasons for doing so:

1. **2D, or "old school," arcade game graphics are far from dead**—The rise of the Internet as a gaming platform has opened many new applications for arcade-style games. Their simpler graphics and relatively light system

requirements make them ideally suited for this new and exciting medium and their use will only increase as more people turn to technologies such as Java™, Flash™, and Shockwave™. For example, ZapSpot, the company where I currently work, has dedicated itself to delivering small 2D-based games to users via e-mail. And they're not alone. Many companies are doing similar things, and 2D graphics and animation techniques are what makes this possible.

2. **2D arcade games still sell**—Despite the computer gaming industry's love affair with 3D game technologies, the popularity of arcade-style games has never really diminished. Rather, it has just taken a temporary back seat to flashier developments. If you doubt this, just look around the store shelves and software catalogs. Arcade games are as popular as ever. Arcade titles such as Epic MegaGames' *Jazz Jackrabbit II*™ and Broderbund's *Loadrunner II*™ have dominated the sales charts for some time. In fact, eight of the ten top selling commercial games of 1998 were 2D based.
3. **2D arcade games are enjoying a comeback**—The growing popularity of emulators such as *MAME*, *iNes*, and *Virtual Gameboy* has only served to reinforce the genre's immortality and has sparked a major resurgence and interest in arcade-style games.
4. **2D arcade game graphics are relatively easy to create**—For the most part, arcade game graphics are much easier to design and create than their 3D counterparts. Furthermore, the fundamental concepts behind their design and use are also much simpler to teach, making the topic ideally suited for users of all levels and competencies. If you can move a mouse and draw simple shapes in a standard graphics package, you can learn how to create arcade-style graphics. Most 3D artwork, on the other hand, requires a significant amount of skill and experience to create, something that only a handful of individuals in the game development industry currently possess.
5. **2D arcade game graphics don't require much time or financial investment to create**—Designing arcade-style graphics can be done with a relatively small investment in terms of hardware, software, and most importantly, time. In fact, all of the graphics examples in this book were created in a matter of hours using software that costs well under $200 and runs on any Pentium class PC. In comparison, it often takes an expensive, workstation class machine running software costing thousands of dollars days to create most 3D-style game artwork.

So, if issues like time, money, and audience factor into your game making plans, learning how to create arcade-style graphics is still an important skill to acquire.

Who is This Book For?

This book is for anyone who is interested in producing arcade-style games. However, for obvious reasons, those of you directly involved in game development either as a hobby or as a profession really stand to benefit the most from the information contained in these pages.

Basically, this book is for you if:

- You're a hobbyist or part-time game developer with impressive programming skills who could not draw game graphics if your life depended on it.
- You're a hobbyist or part-time game developer who can't program but is interested in learning how to design and draw game artwork and animation.
- You're a game designer who wants to learn all you can about how game graphics are made in order to make your games look and play better.
- You're a multimedia developer interested in improving the look and feel of your creations.

As you can see, this book was written to appeal to users of all different backgrounds, skill levels, and experience. Regardless of whether you are a weekend programmer or a classically trained artist, you are bound to find this book a valuable introduction, guide, and reference to the world of developing arcade game graphics.

What Can You Expect to Learn?

In this book you can expect to learn quite a bit, including a number of things about games and graphics that have either never been published before or never been published in one place. In this book, you will learn about:

- **Display Modes**—Every video display mode has a number of distinct properties that can affect your artwork. This book teaches you what these are and how to deal with them.
- **Color in Arcade Games**—Color usage can make or break an arcade game. This book teaches you how to use color to its maximum potential.
- **Arcade Game Animation**—Animation is what makes arcade games come alive. This book teaches you the fundamental techniques behind arcade game animation and breaks the process down into easy-to-understand steps.
- **Game Design and Documentation**—No game can exist without proper planning and documentation. This book teaches game design from the artist's perspective, including how to plan out your projects and write related documentation.

- **Evaluating Tools**—The key to creating high-quality artwork lies in the tools that one uses for the job. This book provides comprehensive information on the best free and low-cost graphics tools available. In addition, it gives you essential information on what to look for when evaluating graphics software for your game projects.
- **Graphic File Formats and Image Compression**—Arcade game graphics could not exist if it were not for image compression and a handful of versatile graphic file formats. This book covers the topic of image compression and identifies the essential graphic formats used in arcade game graphics development.
- **File Management**—Proper file naming and file maintenance is crucial to a successful arcade game. This book provides useful tips on asset naming, file management, version control, and file backup strategies.
- **Fonts**—Arcade games rely on fonts to display all sorts of textual information. This book provides a primer on fonts, font characteristics, and the various font formats available.
- **Creating Graphics for Actual Arcade Games**—Without actual practical application, you can never expect to master the process of creating arcade game graphics. Therefore, this book provides a comprehensive step-by-step example on how to design 2D graphics and animation for a real arcade-style game.

For a more specific breakdown of the concepts and techniques covered in the book, take a look at this chapter-by-chapter breakdown:

Chapter 1: *Arcade Games and Computer Arcade Game Platforms*

Many people tend to group arcade games as one type of game or another. This is incorrect. Arcade games span many types of games. Some share common elements and themes while others don't. This chapter tries to define exactly what an arcade game is and summarizes the primary arcade game genres as well as common arcade gaming platforms.

Chapter 2: *Designing for Different Display Modes*

Different computers offer different video display capabilities. These features directly influence how you eventually create your game graphics. This chapter identifies the various issues you can face when designing arcade game graphics in different video modes on different systems and how you can deal with them.

Chapter 3: *Image Compression and Graphic File Formats*

There are many image formats out there but only a few are actually useful for arcade game development. As such, this chapter provides an overview of image compression and discusses the most important graphic image file formats used in arcade game graphics development.

Chapter 4: *Files and File Management*

When designing arcade game graphics, the artwork you create becomes an asset as valuable as gold. After all, you put immeasurable time, thought, and sweat into creating them, why not do something to ensure that they are protected? This chapter explains how to treat your image files properly as well as safely. Among the topics covered here are proper file naming schemes, file management, file organization, and file backups.

Chapter 5: *Evaluating Graphics Creation Tools*

There are scores of programs available with which to design and create arcade game graphics. The problem is that most of these programs are totally unsuitable for the task. This chapter identifies the most useful tools as well as which features to look for when evaluating graphics software.

Chapter 6: *Essential Graphics Tools*

This chapter includes mini-reviews and exhaustive feature summaries of the 15 best programs you can use to design and create your arcade game graphics.

Chapter 7: *Color and Arcade Game Graphics*

Color is more than just something we see, it's something that we experience. This being said, you need to fully understand color in order to be able to exploit it and use it to its full potential. This chapter provides an overview of color theory and how to effectively use it in your arcade game projects.

Chapter 8: *All About Color Palettes*

For various reasons, many arcade games are limited in the amounts of color they can display. Therefore, you need to choose your colors wisely. This chapter helps you to understand what color palettes are, how they differ across platforms, and how to effectively define your own. From this information you will be in the position to best determine how to select and efficiently choose colors for your game artwork.

Chapter 9: *Arcade Game Animation*

Animation is central to the arcade game experience. This chapter provides an overview of the theory behind designing effective arcade game animation. By breaking down the most commonly used types of arcade game animation sequences into digestible pieces, you will have the basics of how to reproduce virtually any type of animated effect or action.

Chapter 10: *Fonts and Arcade Games*

Arcade games need to display text-based information to represent everything from game scores to instructions. Fonts allow us to display this information both legibly and in various sizes and styles. This chapter provides a primer on fonts and their effective use in arcade-style games.

Chapter 11: *Planning Arcade Game Graphics*

It's unlikely for you to have a successful, not to mention timely and hassle free, game project without a proper plan. This chapter shows you how to plan out an arcade game from an artist's perspective.

Chapter 12: *Hands-On Arcade Game Project—Fish Dish*

As the previous 11 chapters mainly covered design theory, procedures, tools, and technical information, this chapter provides a comprehensive tutorial on designing the graphics and animation for an actual arcade game.

Chapter 13: *Miscellaneous Topics and Final Comments*

This final chapter examines the "missing" topics of arcade game graphics such as the different methods for representing game level backgrounds, sources of inspiration, and where to go next with the information you have acquired over the course of the book.

Appendix A: *Artist Interviews*

Every game artist has different preferences, techniques, and tool preferences. There is no better way to get this information than right from the horse's mouth. Therefore, this section includes two interviews of very talented computer graphic artists.

Here, the interview subjects answer some 21 questions about game graphics design in order to help you, the reader, gain better insight on the tools to use and how to approach arcade game graphics design.

Appendix B: *CD-ROM Contents*

No book on arcade game graphics would be complete without a CD-ROM that contains a library of useful tools and support files. This section describes the contents of the book's accompanying CD-ROM.

As a special bonus, the CD includes some very special graphics tools and several free games to give you inspiration for your own projects.

What You Need Before Beginning

I need to stress that this book doesn't require you to be an artist or even an experienced programmer for that matter. You aren't expected to be able to draw or even code. In fact, the only assumptions this book makes are:

- You have access to a PC-compatible computer running DOS or, preferably, a version of Windows 95, 98, NT 4.0, or 2000 with an SVGA color monitor. Although this book clearly targets the DOS and Windows platforms, users of Macintosh and Linux systems shouldn't despair as many of the concepts, suggestions, and techniques described in this book apply to these systems as much as they do to the DOS and Windows platforms.
- You need to be at least familiar with graphics tools and have a basic understanding of how to use them. While you don't have to be an expert with any particular graphics package, you should at least be comfortable around them. This book is a resource, not a software training manual.
- You need to be both willing and eager to apply what you learn from this book in your own projects. This being said, you should also be patient. Unless you're very lucky or just very talented, you can't possibly expect to achieve professional results from what you learn right away. Designing good arcade game graphics takes time and experience. Just keep this in mind and everything will be fine.

About the Author

Ari Feldman is the creative lead at ZapSpot (`http://www.zapspot.com`) where he is responsible for designing much of the artwork and animation for their line of wildly popular games.

Ari has been designing computer game graphics since 1991 and cut his teeth creating the artwork and animation for a number of well-received shareware, commercial, and freeware titles for the Atari ST and Windows platforms. He is also the creator of *SpriteLib*, an extremely popular collection of animated objects for arcade-style games that counts tens of thousands of users worldwide.

Before coming to ZapSpot, Ari supervised the development of high-profile interactive projects for such companies as Columbia House, iVillage, Compaq, Simon & Schuster, GTE, Lehman Brothers, American Express, Gevalia Kaffe, AT&T, and Lucent Technologies.

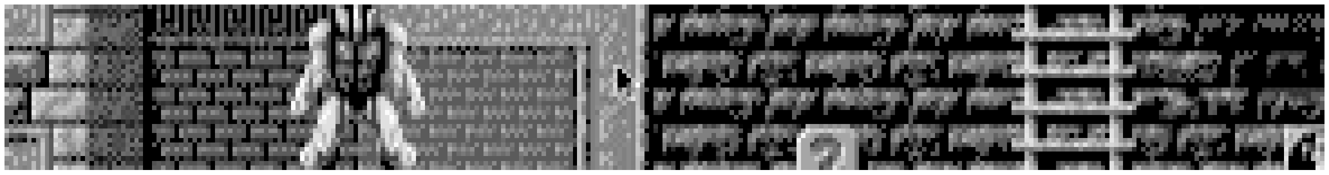
Should you wish to contact Ari, you can always e-mail him at `ari@arifeldman.com` or visit him online at `http://www.arifeldman.com`.

Book Support

The author realizes that despite his best efforts, it isn't always possible to cover every aspect of designing arcade game graphics within the confines of a single book. Therefore, the author has taken the liberty of building a special Web site dedicated to supporting the readers of this book.

Among other things, this site features additional resources including book addendum and errata, and provides a community where interested readers can interact with each other as well as the author in order to further their knowledge on the subjects of arcade game graphics and game design.

Be sure to visit `http://www.gamegfx.com` and tell your friends about it.



Chapter 1

Arcade Games and Computer Arcade Game Platforms

In this chapter, you'll learn about:

- **Arcade game sub-genres**
- **Pong games**
- **Maze/chase games**
- **Shooters**
- **Puzzlers**
- **Platformers**
- **Popular arcade game platforms**

What's an Arcade Game?

Defining exactly what a computer arcade game is can be a difficult thing to do these days, especially when you consider all of the technological advances that have been made in the gaming industry over the years.

An arcade game can be many things and the arcade genre is simply too broad to define with one sweeping statement. You see, arcade games can encompass everything from games with mindless and gratuitous violence to games that require intricate problem solving techniques. To further cloud the issue, the action in an arcade game can take place on a single screen or over multiple levels. These levels can be static or completely dynamic with scrolling occurring in all four directions. And, so on and so on.…

To make the concept of the arcade game somewhat easier to comprehend, I've identified five arcade game sub-genres that run the gamut of the arcade game spectrum.

Arcade Game Sub-Genres

- Maze/chase games
- Pong games
- Shooters
- Puzzlers
- Platformers

Maze/Chase Games

Maze/chase games came into their own during the first arcade game explosion of the early 1980s and eventually would become one of the defining, if not the most endearing, examples of the various arcade genres.

All maze/chase games possess the same basic characteristics: the player navigates an on-screen character through a maze of obstacles to achieve a specific goal. In many instances, this character is being chased by other on-screen characters in an attempt to prevent them from accomplishing their objective.

Maze/chase games are one of the few types of arcade games that actually emphasize strategy over the speed of one's reflexes, although no one can deny that the latter helps too. Maze/chase games come in many flavors and range from the very simple with only a few different game elements to very complex ones that include dozens or even hundreds of different game elements.

It's interesting to point out that virtually all of the action in the average maze/chase game occurs within the confines of a single *playfield*, or game screen. There is seldom any scrolling employed. Instead, these games rely on multiple game levels to keep the user's interest in the game.

Maze/Chase Sub-Genre Examples:

- *Pac-Man* (basic)
- *Dig Dug* (advanced)

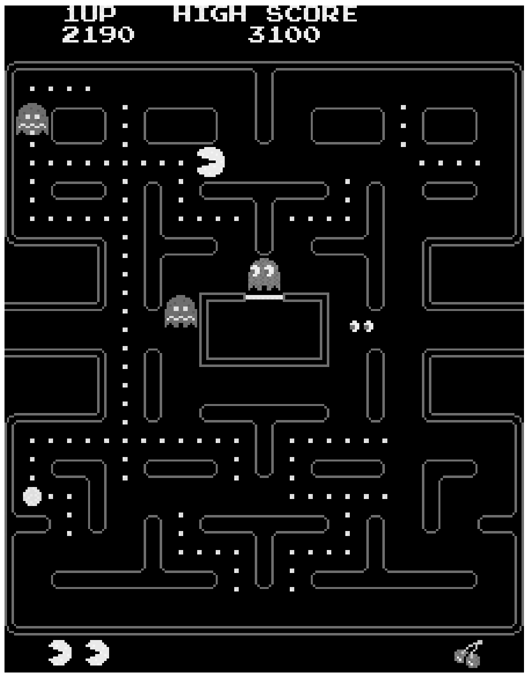


FIGURE 1-1: *Pac-Man™*

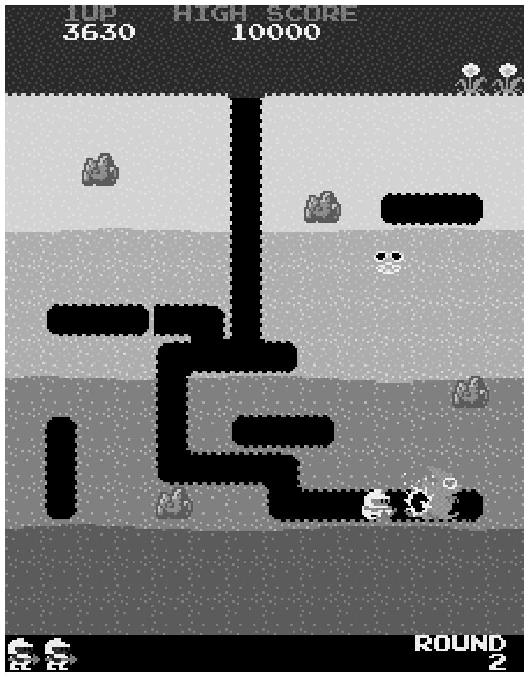


FIGURE 1-2: *Dig Dug™*

Maze/chase games are also unique among arcade games in that they don't usually require very elaborate or sophisticated graphics and animation. Rather, the graphics in these games tend to be more on the simplistic side as these games usually emphasize playability over presentation. In addition, maze/chase games are relatively easy to develop. This makes this game category a perennial favorite with game developers of all levels.

Pong Games

Pong-style arcade games, also occasionally referred to as "bat and ball" games, are among the earliest arcade games developed. They can trace their lineage all the way back to the early 1970s with the advent of the classic *Pong* video game.

All Pong games essentially consist of one or more players manipulating an on-screen paddle device to hit an on-screen ball. In the most basic forms of this sub-genre, the object of the game is to maneuver the on-screen ball past the other player in order to score points. In the more complex examples, the ball is used merely as a device to destroy other game objects such as walls or even creatures. Technically speaking, the Pong arcade sub-genre also encompasses pinball games as well since these games also feature balls that are manipulated by paddles (flippers) to score points, etc.

The action in most Pong-style games usually occurs on static, non-scrolling playfields. However, they often contain many different levels, each with varying degrees of difficulty and challenge.

Pong Sub-Genre Examples:

- *Pong* (basic)
- *Arkanoid* (advanced)

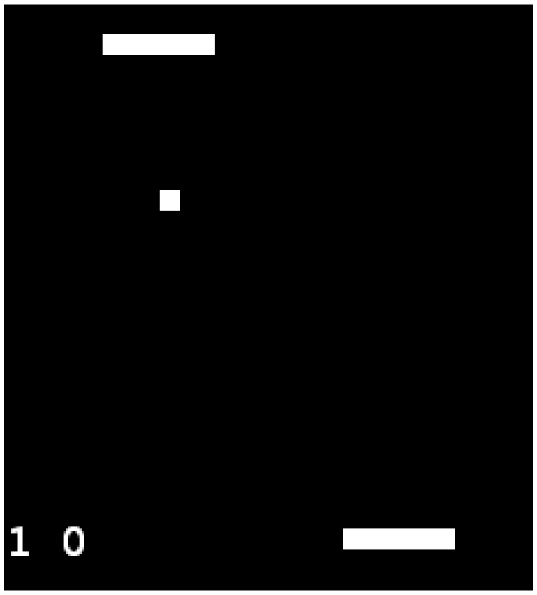


FIGURE 1-3: *Pong™*

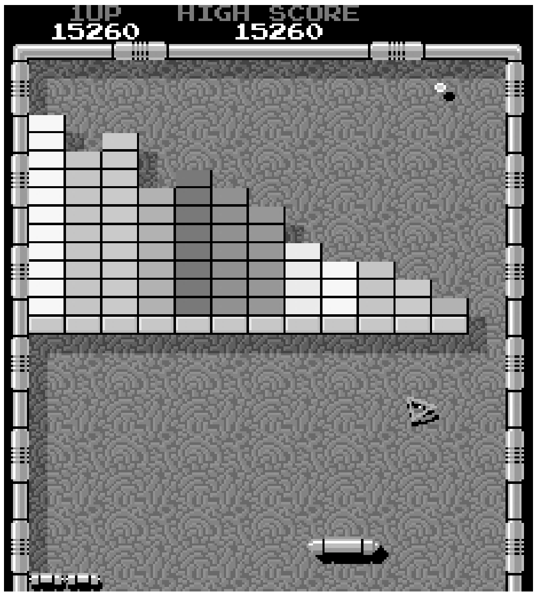


FIGURE 1-4: *Arkanoid™*

The general simplicity of Pong games makes them a favorite among programmers and designers alike, as they are easy to develop. However, don't let this fool you. Some very sophisticated variations of Pong games such as *Arkanoid* have been developed over the years.

NOTE: The original version of *Breakout*, perhaps one of the best implementations ever of the Pong concept, was actually developed in 1974 by none other than Steve Wozniak and Steve Jobs, the founders of Apple Computer. At the time, both of them were engineers at Atari.

Shooters

Arcade game shooters, or “shoot-em-ups” as they’re commonly called, started to appear not long after the first Pong games and remained a dominant force in arcade games from the mid-1980s through the early 1990s.

Shooters are perhaps the broadest of all of the arcade game sub-genres as there have been so many variations developed over the years. Despite this, all shooters share a common theme: one or more players control an on-screen character or object that moves across the screen. This object acts as an aggressor or defender against a horde of on-screen opponents. The goals of the shooter are typically solved through violent action that involves blasting away adversaries before they destroy the player-controlled character. Of all the arcade game sub-genres mentioned here, shooters are the most likely to have no central objective. Rather, the player simply shoots and destroys other on-screen objects for the sake of doing so or simply to score points. As such, shooters tend to emphasize one’s coordination and reflexes over cognitive ability. As with Pong games, there are huge differences in how this activity is implemented.

Shooters also come in two main flavors: *static* and *scrolling*.

Static shooters are limited to the player moving within a fixed area of the screen and firing at an aggressor. Scrolling shooters are offshoots of the static shooter sub-genre. However, unlike static shooters, they free the player from the constraint of moving within a fixed operational area by providing the ability to scroll the playfield in one or more directions. Most scrolling shooters feature two- or four-way screen scrolling which enables the game to feature larger, more sophisticated on-screen objects and game levels.

Shooters, as a general rule, always feature multiple game levels. In this context, these levels are often referred to as “waves.”

Shooter Sub-Genre Examples:

- *Berserk* (static)
- *1943* (scrolling)

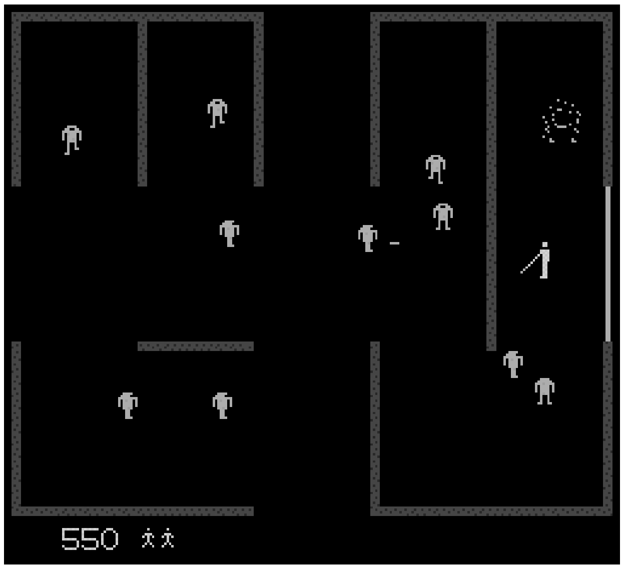


FIGURE 1-5: *Berserk™*

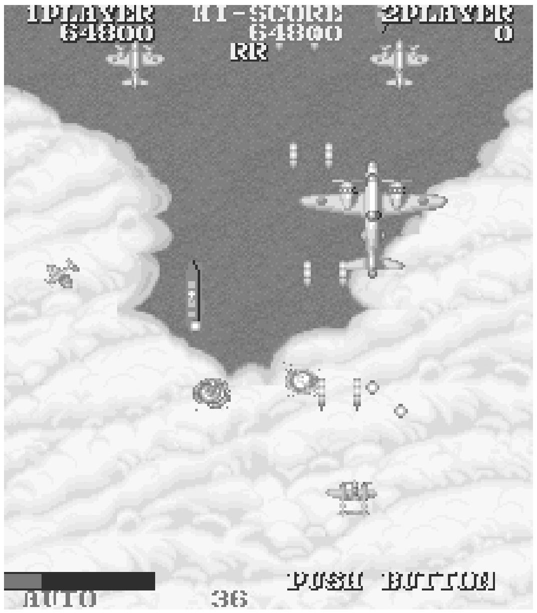


FIGURE 1-6: *1943™*

Just like their themes and objectives, shooters vary wildly in terms of how difficult they are to program and design. This is because each shooter implementation imposes different technical challenges and restrictions on the developer. In addition, most developers need to contend with user expectations. While it takes only a few, simple objects to create a basic but functional shooter, most users now expect shooters to feature very complex and detailed game objects which require more time, effort, and skill to create.

Puzzlers

Puzzlers are just what the name implies—arcade-style games that rely on puzzles to further their plot. While this sub-genre was never as popular as maze/chase and shooter games, it really came into its own on home computers during the late 1980s, as it was able to take advantage of a computer's superior "thinking" ability.

Unlike the other arcade game sub-genres mentioned here, puzzlers don't necessarily rely on fast reflexes to play or enjoy. They certainly can, but usually they tend to stress clear, coherent thought over fast action in order to accomplish the various objectives outlined by the game. This being said, puzzlers work a bit differently than most arcade-style games. Instead of having the player maneuver or shoot his way to the goals, puzzlers emphasize solving a variety of puzzles or problems to accomplish the task at hand. So, in effect, puzzlers are actually learning tools in addition to just being plain fun.

Puzzlers, with very few exceptions, tend to use only one game playfield. However, they tend to make extensive use of multiple game levels, perhaps as much, if not more than the other sub-genres described here, in order to keep them interesting.

Puzzler Sub-Genre Example:

- *Tetris*

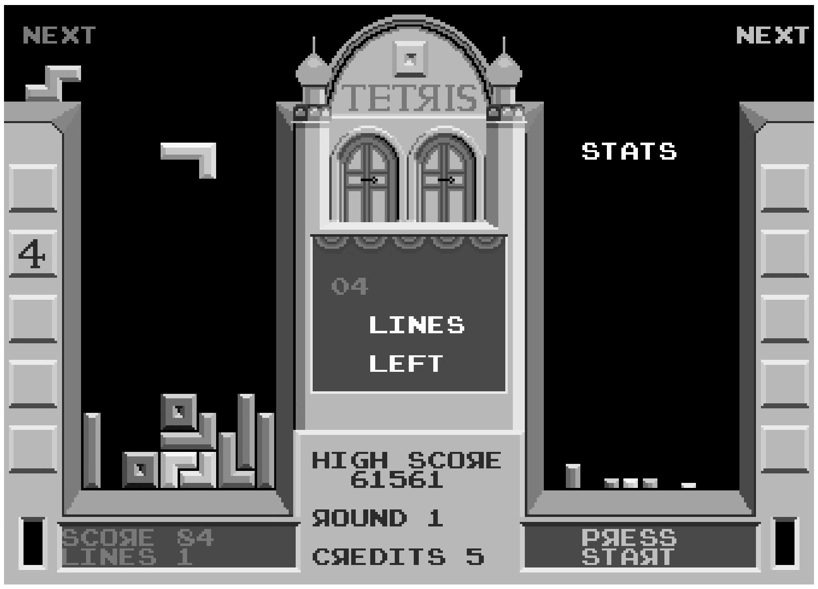


FIGURE 1-7: *Tetris™*

In terms of graphics design, puzzlers sit snugly in the middle of the arcade game graphics "difficulty" spectrum. Their graphics aren't as sophisticated as those featured in shooters but often require more detail than those found in either Pong or maze/chase games. This is probably due to the fact that they need to rely on better visual presentation to convey the ideas and actions required by their puzzles.

NOTE: Puzzlers are chameleons of the arcade game space. They can essentially take on the look and feel of any genre described here and still be considered a puzzler because of their emphasis on thought and strategy rather than hand-eye coordination.

Platformers

Platformers have been around since the earliest days of the arcade games but only really came into their own during the late 1980s with the advent of 16-bit home computers and home video game systems. Since then, platformers have become almost synonymous with the term arcade game.

All platformers share a common plot: the player manipulates an on-screen character, which must overcome a variety of challenges to attain points and achieve a predetermined goal. In addition, all platformers rely on common game elements such as platforms (hence the genre name), bonus objects, and a rich assortment of obstacles and adversaries. This commonality serves to make playing platformers an intuitive process. The logic being that once you've played one, well, you can play them all.

Like shooters, platformers come in two categories: *static* and *scrolling*.

In static platformers, all of the action occurs within a single game playfield that doesn't scroll. However, they make up for this through the extensive use of multiple game levels to challenge the player.

Scrolling platformers, as their name implies, make extensive use of screen scrolling effects. Almost all scrolling platformers scroll their screens left to right; however, quite a few actually support multi-directional scrolling that goes from left to right, right to left, bottom to top, and top to bottom. By their nature, scrolling platformers also rely quite heavily on multiple game levels, which are called "worlds" in platformer parlance.

Platformer Sub-Genre Examples:

- *Burger Time* (static)
- *Gods* (scrolling)

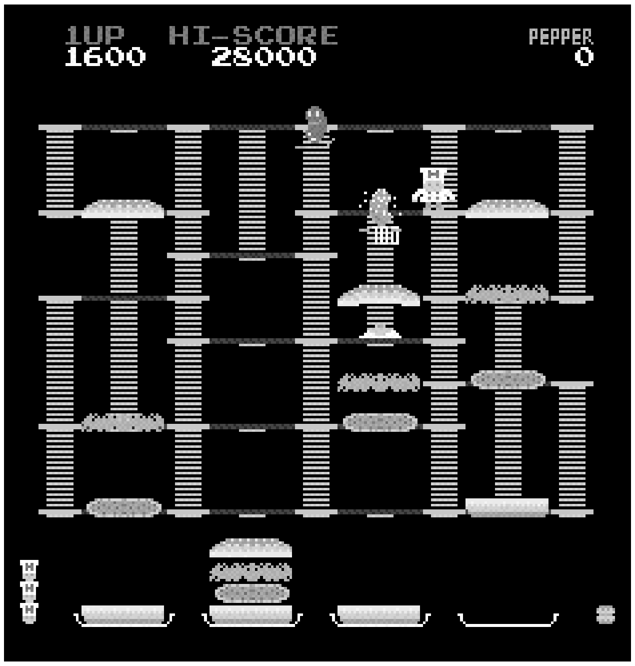


FIGURE 1-8: *Burger Time™*

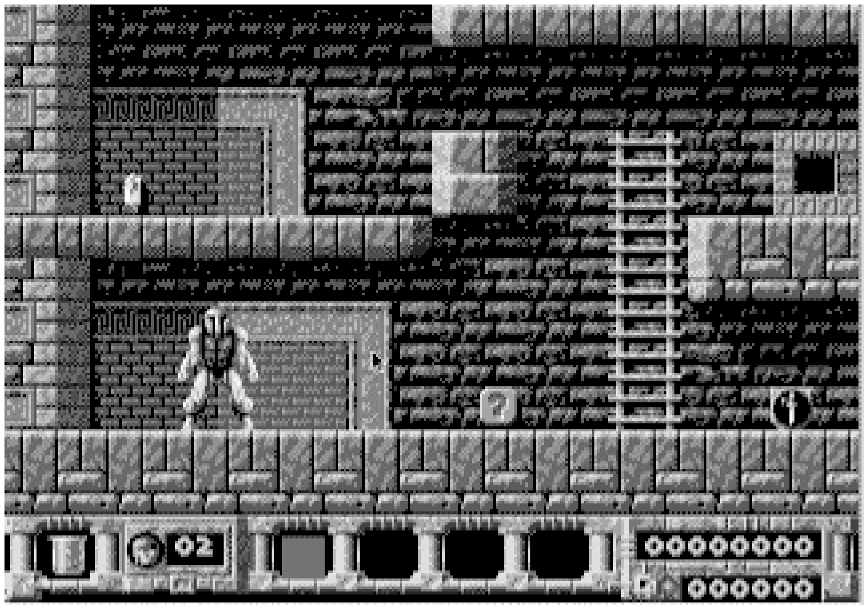


FIGURE 1-9: *Gods™*

Of the arcade game sub-genres mentioned here, platformers are far and away the most difficult to program and design. Why? This is simply due to the fact that gaming technology has advanced to the point where such games have become very sophisticated. Over time, platformers have developed very rich plots and therefore often require highly detailed and emotive screen characters to enhance their appeal to the player. As a result, more precise and time-consuming artwork needs to be created in order to make such games a success.

This Book and Arcade Games

In order to help you practice what is preached, this book examines how to create one of these arcade game genres in detail: a maze/chase game.

Games of this type are excellent learning tools due to their use of vivid color, simple artwork, and relatively easy-to-create animation. Once you master designing the artwork and animation for this genre, you will have the basic knowledge you need to tackle virtually any arcade game project, regardless of its size, theme, style, or complexity.

Computer Arcade Game Platforms

Now that you have an introduction to arcade games and the different arcade game genres that exist, you should know what *platforms*, or systems, they can run on.

There are many computer arcade platforms available but only a few of them are actually viable options these days. These platforms are:

- DOS
- Windows®
- Macintosh™
- Linux
- Java™
- Video game consoles

DOS

DOS (which includes MS-DOS , PC-DOS , and 100% clones such as DR-DOS) used to be the dominant platform for arcade games running on personal computers from the mid-1980s up until the mid-1990s. However, its days as the premier arcade game platform are fading fast. Although a number of hobbyists and small publishers still make games for DOS, very few commercial programmers actually do. This is mainly due to the increasing influence of Windows in game development circles and Microsoft's declining support for the DOS platform as a whole.

DOS is a 16-bit operating system. This makes it slower in many computing tasks compared to today's modern 32-bit (and soon 64-bit) operating systems. Despite this, DOS still enjoys healthy support from game developers and gaming enthusiasts alike. For one thing, DOS's ability to access the PC's graphics hardware directly gives arcade games the speed and performance that they require for fast action and smooth animation. Second, there's a tremendous wealth of DOS-related game development tools and reference materials floating around. In fact, some of the best arcade game development tools and graphics packages are completely DOS based. Third, DOS is relatively simple to program when compared to other platforms such as Windows. This makes it a good choice for beginners interested in learning how to design, program, and create artwork for arcade games. Finally, DOS is also backwardly compatible with the tens of millions of Windows 3.1, 95, and 98 systems installed around the world, ensuring that there will be an audience for DOS games for some time to come.

Windows

Microsoft's Windows operating system is by far the most dominant computing platform at this time. It's also the current "gold standard" of arcade game platforms. The vast majority of today's game releases are made specifically for the Windows platform. In addition to running over a hundred million machines worldwide, the most recent implementations of Windows utilize DirectX technology, which makes high-performance arcade gaming experiences finally possible on that platform.

There are several variations of Windows that exist, including:

- Windows 3.1
- Windows 95
- Windows 98
- Windows NT
- Windows 2000

Each version addresses different market segments and offers different features.

Windows 3.1 is an older, 16-bit version of Windows that's really little more than a fancy GUI (graphical user interface) shell that runs over a DOS core. Yet, despite its lack of technical sophistication, Windows 3.1 helped make Windows a popular operating system with consumers around the world. Even so, Windows 3.1 never really caught on as an arcade game platform due to its relatively poor graphics performance. A fair number of people still use Windows 3.1, but like DOS, its user base is shrinking rapidly.

Windows 95 was the long-awaited, 32-bit rewrite of Windows 3.1 that was released in 1995. It successfully married the Windows interface with the power and performance demanded by modern arcade games. Windows 95 is by far the most popular version of Windows and virtually all arcade games and game development tools are made to run under it.

Windows 98 was released in 1998 as an enhancement to Windows 95. It improved on Windows 95's gaming features and added integrated DirectX support, which makes for even better arcade game performance.

Windows NT was developed in parallel with Windows 3.1 but was designed from the start as a 32-bit, business-grade operating system. After years of following a different development path, Microsoft finally gave NT a Windows 95-like interface and repackaged it as Windows NT 4.0. NT 4.0 was the first version of that operating system to appeal to both consumers and businesses. Although NT looks and acts like the other versions of Windows, it's different enough internally to ensure that not all Windows games will run on it.

Windows 2000 is the new kid on the Windows block. At the time of this writing, it has just been released. Despite its interesting name, it's basically just an enhanced version of Windows NT with a few additional features and enhancements, particularly in the area of multimedia. Although Windows 2000 is specifically targeted to business users, there's little doubt that it will run its share of Windows-based arcade games as well.

If you want to develop games for a living or create graphics for them, you'll probably do it on a Windows-based machine. Virtually all of the latest graphics and game development tools are available for the Windows platform and that's not likely to change in the foreseeable future.

Macintosh

First introduced in 1984, the Macintosh changed the way we interacted with computers by allowing us to perform routine operations with windows, icons, and a click of the mouse. Since that time, there have been many permutations of the Macintosh produced and it developed an incredibly loyal and passionate following among its users.

For a time, particularly during the late 1980s, the Macintosh was actually a very popular gaming platform. However, as Apple's fortunes changed during the early to mid-1990s, the Macintosh's market share dropped significantly and game developers abandoned the platform in droves. However, with Apple's recent resurgence, this downward trend has finally reversed and the Macintosh is once again becoming a viable arcade gaming platform. Even so, the Macintosh pales in comparison to Windows in terms of the number of installed machines, the selection of development tools, available hardware extras, and games being released. This being said, you can still develop some impressive games and game graphics on the Macintosh platform, but you'll have many more options and alternatives available to you on the Windows platform.

Linux

Linux is a free, UNIX variant that has become an increasingly popular alternative to Windows and the Macintosh operating systems due to its low cost, superior performance, and legendary reliability. As one of the fastest growing platforms in the marketplace, it's not surprising that there's been a flurry of recent Linux-oriented game development activity. In fact, a number of popular Windows and Macintosh games have already been ported over to the Linux platform. If the pace of innovation and development continues, there is little doubt that Linux will become an important arcade game platform capable of giving any system a run for its money.

Java

Unlike the other platforms mentioned here, Java isn't really an operating system or hardware system (although Java versions of both do exist) per se, but rather a programming language developed by Sun Microsystems. Programs, once written in Java, can theoretically run on any Java-enabled system in a consistent manner, including arcade games.

There are three things that make Java an important arcade game platform: a large audience, strong graphics support, and universal compatibility. Java enjoys an extremely large installed user base. Essentially, anyone with a modern Web browser can run and play Java-based games. This ensures developers the widest possible audience and provides them with plenty of incentive to develop games. In addition, recent incarnations of Java provide support for a whole slew of graphics features that make it well suited as a game platform. Finally, as Java can run on almost any computer system or device, it's possible to play the same game whether you're using a Windows, Macintosh, or UNIX system.

The only limitation that Java faces as a gaming platform is slow performance. At this time, Java's speed still doesn't match that of traditional computer programming languages such as C++. However, Java is more than capable of providing most types of arcade games with acceptable performance. And, as time goes by, its performance will only improve. When this finally happens, Java will be the arcade game platform to watch.

Video Game Consoles

Video game consoles have been around since the late 1970s with the introduction of the first home versions of *Pong*. They became entrenched in consumer consciousness during the early 1980s when home video consoles like the Atari 2600, Intellivision, and Colecovision came on to the scene. Then, once the arcade game industry crashed in 1983, they vanished almost as quickly as they came. It wasn't until the late 1980s with the introduction of a new generation of home video game consoles by companies such as Sega and Nintendo that they once again captivated arcade game players everywhere.

Currently, there are several video game console models that stand out as popular arcade game platforms. These include:

- Nintendo Gameboy
- Sega Genesis
- Super Nintendo
- Sony Playstation
- Nintendo 64
- Sega Dreamcast

The Nintendo Gameboy is an 8-bit, hand-held gaming system. Many of its games mimic the earlier Nintendo Entertainment System in terms of look, feel, and performance. This platform is well suited for scrolling platform games and puzzlers but little else due to its small screen size and relatively puny processing power.

The Sega Genesis is a 16-bit video game system that was state of the art when it was introduced back in 1989. Although it's somewhat dated compared to today's modern systems, it virtually redefined the arcade game platformer genre with the release of titles such as *Sonic the Hedgehog*. This platform is well suited for all types of arcade games from shooters to complex, scrolling platformers.

The Super Nintendo is a 16-bit video game system in the same vein as the earlier Sega Genesis. Its main claim to fame was an innovative graphics subsystem that allowed its games to feature some very impressive color and special object rotation effects. Like the Genesis before it, this platform is powerful enough to handle the most demanding arcade game.

Sony's Playstation was the most successful of the 32-bit video game consoles developed. It's also the most popular gaming-dedicated gaming platform currently around and boasts an installed base of tens of millions of units. Its powerful graphics capabilities allow it to run some of the most sophisticated arcade games ever developed.

The Nintendo 64 was Nintendo's third-generation video game console. A 64-bit system, it features sophisticated, custom graphics hardware developed by Silicon Graphics that enables it to produce extremely vivid graphics and animation. Like the Playstation, it too can handle any arcade game with ease.

Lastly, there's Sega's Dreamcast. This is the first 128-bit video game console on the block. It has all of the features and capabilities needed to take arcade gaming to the next level.

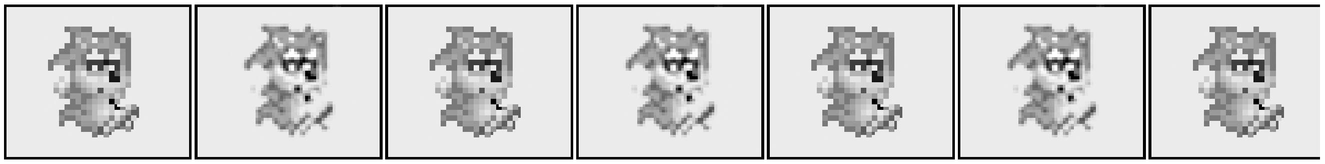
As you can probably imagine, the video game console market is huge. There are literally millions of installed systems from every manufacturer and of every variety in homes across the world. As such, video game consoles are an extremely viable arcade game platform. There's no shortage of software for them and they're likely to remain popular for some time to come.

Table 1-1 provides a summary of the pros and cons of each platform we've just discussed.

TABLE 1-1: Summary of Arcade Game Platforms

Platform	*Pros*	*Cons*
DOS	■ Offers excellent screen performance which makes for fast games ■ Has a large installed user base ■ Has many good development tools available for it ■ Easy to develop on, which makes it good for beginners.	■ Based on archaic technology that's really starting to show its age ■ No longer Microsoft's flagship product, thus support for it is rapidly waning

Windows	■ Offers very good screen performance, which makes for fast games ■ Enjoys the largest installed user base of any arcade game platform ■ An accepted industry standard arcade gaming platform ■ Lots of development tools available for it ■ Supports a wide array of machines and hardware	■ Somewhat difficult to develop for
Macintosh	■ Offers good screen performance for most types of arcade games ■ Has an extremely loyal and productive user base	■ Limited development tools available compared to Windows and DOS ■ Somewhat difficult to develop for and not really suitable for beginners ■ Has a much smaller user base compared to Windows
Linux	■ Offers good screen performance for fast games ■ Has an extremely loyal and productive user base ■ Enjoys a rapidly growing user base	■ Limited number of development tools available for it ■ Somewhat difficult to develop for and not really suitable for beginners
Java	■ Enjoys a very large installed user base ■ Lots of development tools are available for it ■ Offers developers a "write once, run many" approach to game development ■ Supports a wide array of systems and platforms ■ Flexible and extensible	■ Somewhat difficult to develop for and not really suitable for beginners ■ Relatively slow screen performance currently limits the types of games it can run
Video game consoles	■ Their excellent screen performance makes for fast games ■ Enjoys a very large installed user base ■ An accepted industry standard arcade gaming platform	■ Limited development tools available ■ Development is prohibitively expensive for most users due to licensing costs ■ Somewhat difficult to develop for and not really suitable for beginners



Chapter 2

Designing for Different Display Modes

In this chapter, you'll learn about:

- **Video hardware standards**
- **Display modes**
- **Screen resolutions**
- **Aspect ratios**
- **Refresh rates**
- **Color capabilities**
- **Gamma levels**
- **Choosing display modes to design for**
- **Specific display mode recommendations**
- **Rules for display mode selection**

A Summary of Video Hardware Standards

The purpose of this section is to summarize the historical significance of the various video hardware standards that have emerged since the advent of the personal computer in the early 1980s. These standards include:

- Color graphics adapter (CGA)
- Enhanced graphics adapter (EGA)
- Video graphics adapter (VGA)
- Multicolor graphics array (MCGA)
- Super video graphics adapter (SVGA)

Color Graphics Adapter (CGA)

The CGA was one of the first video hardware standards to appear on the market. IBM introduced it in 1981 as a display option for their then fledgling line of personal computers. The CGA standard enabled graphics to be created in color (a major coup at the time) and offered three different levels of graphics resolution: low, medium, and high.

Although technically primitive by today's standards, the CGA was an important milestone in the annals of graphics development. It not only introduced color graphics to the PC-compatible world, but it also helped establish the 320x200-line video mode as an industry screen resolution which was adapted by scores of other systems like the Commodore 64, Amiga, Atari ST, Apple IIGS, and a number of home video game systems.

Virtually all PC graphics systems are backwardly compatible with the CGA standard. This means that they can use software specifically written for any of its video modes. However, it's important to point out that the CGA hasn't been supported by commercial arcade games since the late 1980s and is widely considered to be obsolete.

NOTE: Only DOS continues to support the CGA standard and even that support is limited to running old software.

Enhanced Graphics Adapter (EGA)

IBM introduced the EGA as a replacement for the CGA standard in 1984. The EGA's hardware could emulate the CGA video modes as well as use its own, improved graphics capabilities.

As with the CGA, the EGA's days as a graphics standard were relatively short-lived. The EGA was eclipsed by more powerful graphics standards by the late

1980s. The EGA's main contribution to the evolution of arcade games was the fact that it was very popular among PC game programmers due to its ability to display vibrant color (for that time) and support smooth animation via page flipping. In fact, such PC arcade game classics as *Duke Nukem* made their debut on EGA-compatible hardware.

NOTE: Only DOS and Windows 3.1 continue to support the EGA.

Video Graphics Adapter (VGA)

IBM introduced the VGA in 1987 for use in its higher-end PS/2 systems and as a replacement for the EGA standard. The VGA raised the bar of PC graphics capabilities—not only in terms of graphics resolution but also in its ability to display vivid color. The VGA was the first widely adopted video standard to provide support for analog color monitors, which allowed thousands of colors to be displayed instead of the 16 that were commonplace.

The VGA standard became very popular with game developers due to its ability to display many distinct shades of color on-screen at once. Virtually all arcade games written today are still designed with VGA compatibility in mind.

Although now somewhat dated in terms of features, the VGA standard represents the minimum display capabilities offered by any modern computer system.

NOTE: DOS, Windows 95/98/NT/2000, Linux, and Macintosh systems all support some version of the VGA standard.

Multicolor Graphics Array (MCGA)

The MCGA was a reduced-function version of IBM's VGA hardware standard. It first appeared in 1987 with IBM's introduction of its low-end Model 25 and Model 30 PS/2 computer line.

All MCGA display modes are 100% compatible with those supported by the VGA standard. As a result, MCGA-equipped systems can play almost all of the same games one can with a VGA-equipped system.

NOTE: Only DOS and Windows 3.1 continue to support the MCGA standard. Windows 95/98/NT/2000, Linux, and Macintosh systems do not.

Super Video Graphics Adapter (SVGA)

The SVGA evolved during the early 1990s as a means of taming the market chaos that occurred when different hardware manufacturers attempted to improve on the VGA's core technology without following a common hardware standard.

Video hardware that adheres to the SVGA standard supports additional graphics resolutions as well as the ability to display thousands and millions of colors. At the same time, it is fully backward compatible with all software written for the VGA, EGA, and CGA display standards.

Since its introduction, the SVGA has taken arcade games to a new level by allowing them to support higher resolutions and more colors that users demand, and it remains the current display standard across all computer platforms.

NOTE: DOS, Windows 95/98/NT/2000, Linux, and Macintosh systems support all elements of the SVGA standard.

Display Modes

Display modes, or *video modes*, define how graphic images appear on a given machine. Each video hardware standard supports different display mode capabilities. Meanwhile, every display mode has a number of unique characteristics associated with it. These characteristics determine everything from screen width to the number of colors that can be displayed at a time.

As a designer, it's important to get to know these characteristics and understand how they can influence the artwork you create. Specifically, you should concern yourself with these issues:

- Screen resolution
- Aspect ratio
- Refresh rate
- Color capability
- Gamma level

Screen Resolution

As you probably already know, all computer-generated images are composed of *pixels*, which are the smallest graphic elements that you can manipulate. Screen resolution measures the actual number, or the density of pixels per a horizontal and vertical screen line.

The basic law of screen resolution is this: the higher the screen resolution, the greater the amount of graphic detail and information that can be displayed, as illustrated by Figure 2-1. In this example, the top figure represents an object rendered at low resolution while the bottom figure represents the same object when displayed at a high resolution.

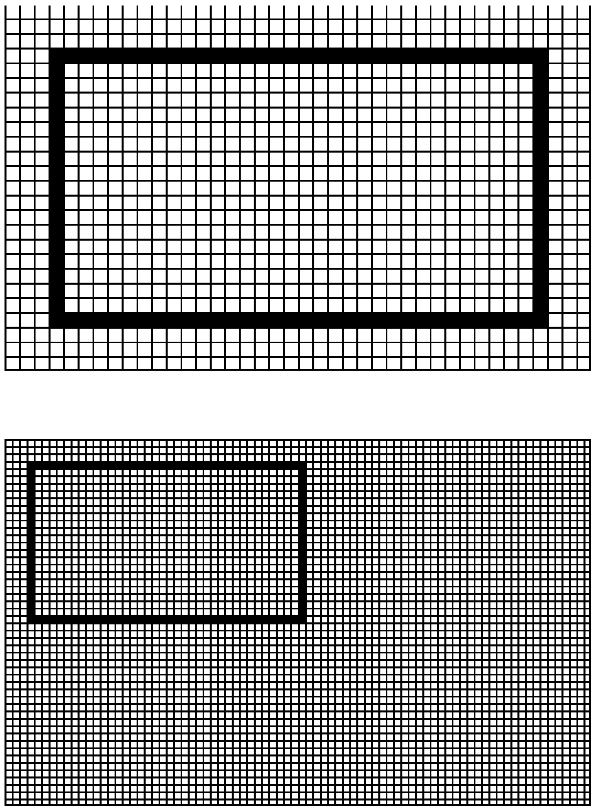


FIGURE 2-1: Screen Resolution Example

Multiplying the number of horizontal pixels (X) by the number of vertical pixels (Y) produces the total number of pixels that are supported at a given screen resolution. For example, a screen resolution that is 640 pixels wide by 480 pixels tall is said to have 307,200 pixels available. Screen resolutions are commonly referred to using this formula, i.e., 640x480.

Why It's Important

Screen resolution is important for two reasons. First, it defines how much detail we can see or create on a given screen. Second, it influences the quality of how we see this information.

The average, unaided human eye can resolve objects as small as .05 millimeters. However, even the most sophisticated computers can't come close to producing images with that level of detail. Instead, most computer-generated images look blocky and coarse when compared to common print materials such as books or magazines.

When irregular graphic shapes such as diagonal lines or circles are displayed on-screen, their shape and appearance has to be approximated. This approximation produces an unfortunate byproduct called *aliasing*. Aliasing is the stair step-like pattern that gives computer-generated artwork its distinct digital look, as shown in Figure 2-2. Fortunately for us, as the screen resolution increases, so does the density of the pixels available per screen line. This effectively minimizes the impact of aliasing and makes graphic objects appear smoother than they really are.

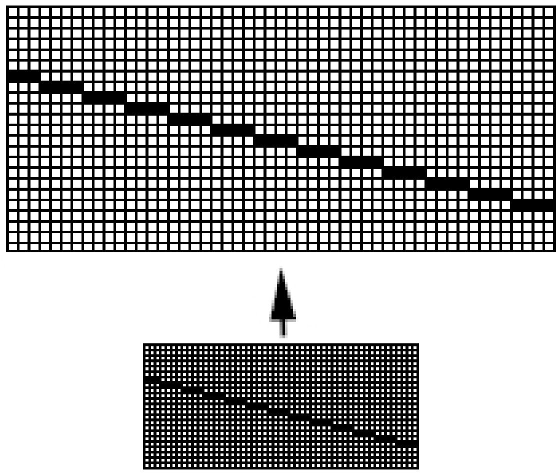


FIGURE 2-2: Aliasing

Screen resolution also has a direct influence on image quality. Using higher screen resolutions will always give your artwork higher fidelity over lower screen resolutions. Figure 2-3 shows some examples of this. Both objects A and B are identical but are rendered at different resolutions. If you look closely, you'll notice that object A looks much coarser than object B due to its lower resolution.

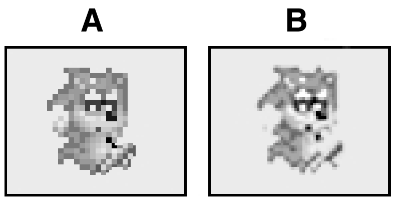


FIGURE 2-3: Screen Resolution and Image Quality

Given the sophistication of today's computers, people will demand and expect games that feature clear and crisp graphics. Don't disappoint them.

Today's computers are capable of displaying a variety of different screen resolutions. Table 2-1 lists the most common of these.

TABLE 2-1: Common Computer Screen Resolutions

Operating System	*Resolution Name*	*Supported Screen Resolution*	*Total Pixels (X*Y)*
Linux	Medium	640x480	307,200
Linux	High	800x600	480,000
DOS	Medium	320x200	64,000
DOS	Mode X	320x224	71,680
DOS	Mode X	320x240	76,800
DOS	Mode X	320x256	81,920
DOS	Mode X	320x480	153,600
DOS	Mode X	360x200	72,000
DOS	Mode X	360x224	80,640
DOS	Mode X	360x240	86,400
DOS	Mode X	360x256	92,160
DOS	Mode X	360x400	144,000
DOS	Mode X	360x480	172,800
DOS	Mode X	640x400	256,000
DOS	VGA	640x480	307,200
DOS	SVGA	800x600	480,000
Mac OS	14" Monitor	640x480	307,200
Mac OS	15" Monitor	800x600	480,000
Windows 3.1	Medium	640x480	307,200
Windows 3.1	High	800x600	480,000
Windows 95/98/NT/2000	Low	320x200	64,000
Windows 95/98/NT/2000	Medium	640x480	307,200
Windows 95/98/NT/2000	High	800x600	480,000

NOTE: The average 17-inch computer monitor can support screen resolutions of 1024x768 but very few arcade-style games actually run in that resolution. Therefore, we won't cover this resolution.

Mode X is a non-standard software modification of the standard VGA display modes. In addition to providing additional screen resolution, Mode X offers improved performance for most graphics operations, including complex arcade game animation. It's interesting to point out that all of the so-called DirectX display modes are also Mode X display modes in disguise. For the purposes of this discussion, only the most commonly used Mode X resolutions are mentioned here. Also, be aware that Mode X resolutions aren't typically available on non-PC hardware (i.e., the Macintosh) because of differences in video hardware architecture.

Screen Resolution Issues

Failing to take screen resolution into account while designing your arcade game graphics can have disastrous results. Here are three important issues to consider when dealing with screen resolution:

- Graphics production time
- DPI differences
- Platform compatibility

Graphics Production Time

Even experienced designers find that creating high-quality game art takes lots of time, precision, and patience to do well. As such, it's not a process that takes kindly to being rushed. Once you get into a project, you'll often find that it can take you hours or even days to make a particular graphic object look just the way you want it.

This being said, it's important to understand how screen resolution can influence the time it takes you to create your game artwork. These influences include *screen real estate*, *subject matter*, and *comfort level*.

Screen Real Estate

The higher the screen resolution, the more on-screen "real estate" there is for you to contend with. For example, if you were designing in a relatively low screen resolution like 320x200, you would be working with 64,000 pixels. However, if you were designing in a 640x480 resolution, you would be working with 307,000 pixels, and so on. That's a huge increase in on-screen area, 4.8 times more to be exact. This extra screen area means that there's more screen space to fill in with your objects. This in itself can negatively impact how long it takes you to create your graphics.

Subject Matter

The subject matter of your artwork can also make a big difference on how long the graphics creation process takes. For example, very simple artwork, such as those composed of simple shapes, probably won't be affected by screen resolution very much. However, very complex artwork that features intricate shapes and patterns might be affected, as such artwork tends to be more susceptible to visual anomalies that higher screen resolutions can reveal.

Comfort Level

Finally, your comfort level with designing at different screen resolutions can be a big factor on how long it takes you to create graphics for a given project. For example, an artist comfortable with designing at one resolution may not feel comfortable designing artwork at another. This is because most graphic artists tend to learn how to create game graphics at a specific resolution and, over time, adjust their drawing styles to match the particular quirks and eccentricities exhibited by that resolution. As a result, many artists aren't able to easily adapt to a different screen resolution without a significant amount of retraining and practice. For example, if you're used to drawing your artwork at a resolution of 320x200 and suddenly have to work at a resolution of 640x480 for a project, you may be in for a rude awakening. You'll quickly discover that the pixel size and orientation of this screen resolution has totally changed, potentially throwing you off and slowing you down.

In any case, be sure to consider these issues thoroughly before you tackle a project and make sure you set aside enough time to handle any such contingency. You have been warned!

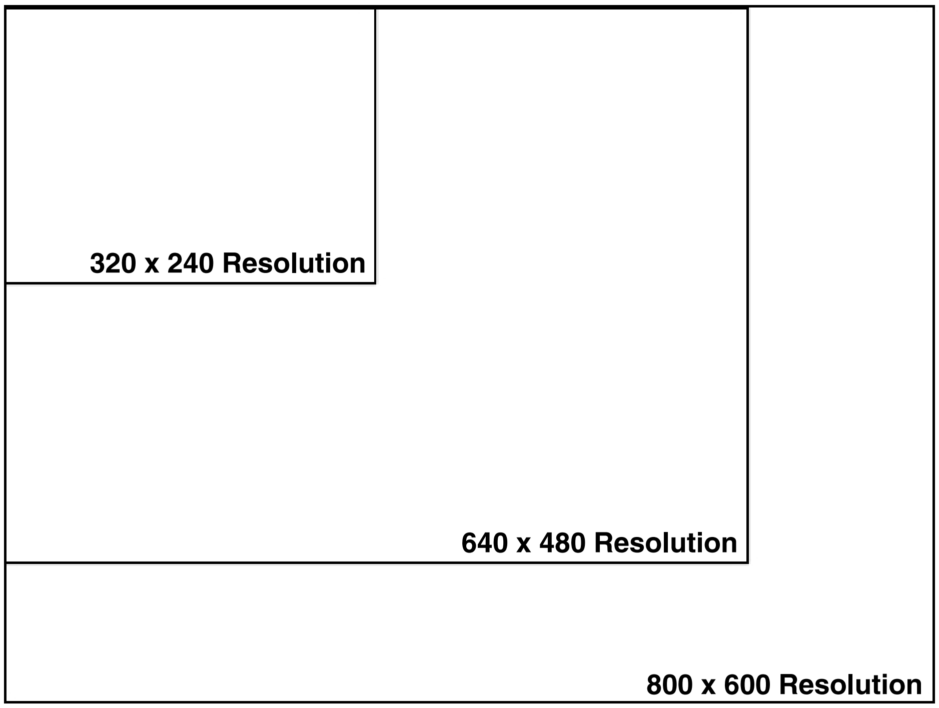


FIGURE 2-4: Comparison of Different Screen Resolution Sizes

DPI Differences

Screen resolution is also sometimes specified as DPI, or dots per inch. DPI is important to consider because it influences how different images display at various screen resolutions and monitor sizes. For example, an image created at a resolution of 640x480 on a 15-inch monitor will appear larger when shown on a

19-inch monitor at a resolution of 640x480. This is because the pixels on the larger monitor are less dense than on the smaller monitor. This has the effect of making your artwork appear blocky in addition to revealing potential design flaws, etc. Table 2-2 illustrates these DPI differences on various monitor sizes.

TABLE 2-2: DPI Differences at Common Screen Resolutions

Screen Resolution	*Estimated DPI 14" Monitor*	*Estimated DPI 15" Monitor*	*Estimated DPI 17" Monitor*	*Estimated DPI 19" Monitor*
320x240	32	30	25.6	22
360x200	37	34	29	25
640x480	66	60	51	44
800x600	82	75	64	56

NOTE: You can roughly estimate the DPI supported by a given monitor by using the formula X/S, where X is the horizontal screen resolution and S represents the width of the displayable picture of the monitor in inches. For example, a 15-inch monitor with a viewable picture area of 10.6 inches and a screen resolution of 640x480 would yield a DPI of 60.

NOTE: While Windows, the Macintosh, and Linux all have different system DPI specifications of 96, 72, and 75 DPI respectively, these differences only influence text fonts and not bitmapped graphics as used in arcade games. Figure 2-5 shows some examples of how DPI can influence the appearance of graphic images.

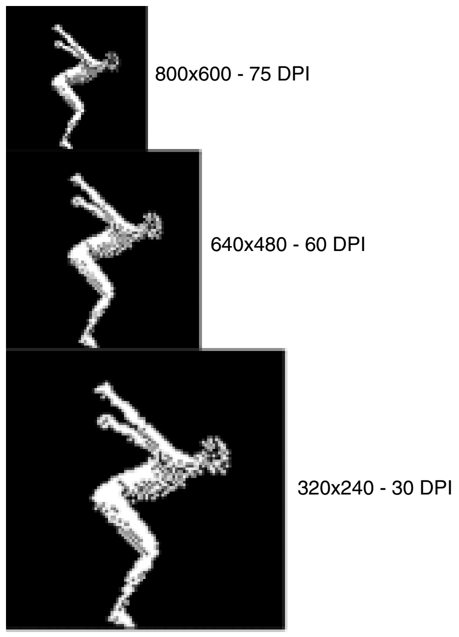


FIGURE 2-5: DPI and the Appearance of Graphic Shapes

Platform Compatibility

Despite the fact that computers are capable of supporting many different screen resolutions, only a few of these resolutions are actually common across multiple platforms. For example, screen resolutions such as 320x200, 640x480, and 800x600 are commonly found on several different systems, while screen resolutions such as 360x200 are platform specific and proprietary.

To play it safe, avoid designing in proprietary screen resolutions unless you have a very specific need to do so. Proprietary screen resolutions tend to complicate matters, especially when trying to port your artwork from one platform to another. Instead, plan on designing your game artwork at those screen resolutions that you know to be compatible with and common across different arcade game platforms.

NOTE: Most of the so-called Mode X screen resolutions are considered to be proprietary and aren't recommended unless you and your development team have made a conscious decision to do so.

A specific screen resolution is considered compatible when it is supported by all major computer platforms as identified in Table 2-3.

TABLE 2-3: Compatible Screen Resolutions across Platforms

Screen Resolution	*DOS Compatible*	*Windows 3.1 Compatible*	*Windows 95/98/NT/2000 Compatible*	*Macintosh Compatible*	*Linux Compatible*
320x200	✓	+	✓		
320x240	✓	+	✓		
640x480	✓	✓	✓	✓	✓
800x600	✓*	✓	✓	✓	✓

* Above 640x480 in 16 colors, DOS needs a third-party video driver to support these resolutions.

+ These screen resolutions are not native. DOS programs that use them should run, but Windows 3.1 does not support these resolutions.

What You Can Do

- You can ensure the image quality of your game artwork by always choosing a higher screen resolution over a lower screen resolution. However, don't make the mistake of assuming that using a high screen resolution will always make your game artwork better, because it won't. Using high screen resolutions can be a double-edged sword. It can just as easily make your graphics look worse by revealing subtle (and not-so-subtle) design flaws in your artwork, i.e., sloppiness, poor style, and the like. Also, for performance and compatibility reasons, using a high screen resolution won't always be an option that's available to you. Fortunately, it happens that many games can work well at lower screen resolutions as well. Refer to Table 2-11 to see some examples of this.

- You can actually speed up the graphics creation time for most game projects by cheating. For example, if your game doesn't require very high-resolution objects, consider creating your graphics using a lower screen resolution instead, i.e., use 320x240 instead of 640x480 or 640x480 instead of 800x600, etc. If the lack of image quality concerns you, don't let it worry you too much. You can often make up for the lack of overall resolution by strategically using color. Color, as we'll see later in Chapters 7 and 8, has the unique ability of being able to simulate resolution through clever shading. What's more, there are many instances where fast animation or certain game styles (i.e., "retro") can minimize the impact of not having very highly detailed graphic objects present. This is because most users psychologically won't perceive the lack of detail once they become engrossed in the game's action.
- Unfortunately, you can't control how different monitors handle DPI at different screen sizes, as there is simply too much variation possible. However, you might be able to anticipate how some systems will render your artwork by testing your artwork at different screen sizes prior to incorporating it into a game. This way, you might be able to make some changes that will minimize the flaws and defects that might be exposed in your artwork on different sized monitor screens.
- To avoid graphics compatibility and porting problems between major arcade game platforms such as the PC or Macintosh, always try to design your artwork using a commonly supported screen resolution. For example, 640x480 is compatible with Windows, Linux, and Macintosh machines, while 320x200 is largely compatible with DOS, Windows, and many dedicated video game consoles (i.e., Super Nintendo, etc.).

Aspect Ratio

An important, but little known fact is that most popular screen resolutions are horizontally oriented and actually appear rectangular when displayed, and not square. Therefore, they are said to have an *aspect ratio*, or the ratio of horizontal pixels to vertical pixels, of 4:3. In other words, the images on these screens are 1.33 times wider than they are tall. We refer to this measurement as the *horizontal aspect ratio* of an image.

Why It's Important

Aspect ratio is important because it helps to ensure that geometric shapes such as circles, curves, and diagonal lines are displayed on the screen correctly. In order to achieve this, however, some screen resolutions, such as those with 4:3 aspect ratios, actually change the shape of their pixels from rectangles to squares. Doing this keeps whatever appears on the screen looking proportional and consistent. So, for example, a circle drawn on such screens will appear as a circle rather than an ellipse.

Figure 2-6 illustrates how aspect ratio affects screen shapes while Figure 2-7 compares the pixel shapes of different screen resolutions. The figure on the left represents an image rendered at a perfect 4:3 aspect ratio while the figure on the right shows the same image when displayed on a screen that doesn't support a 4:3 aspect ratio.

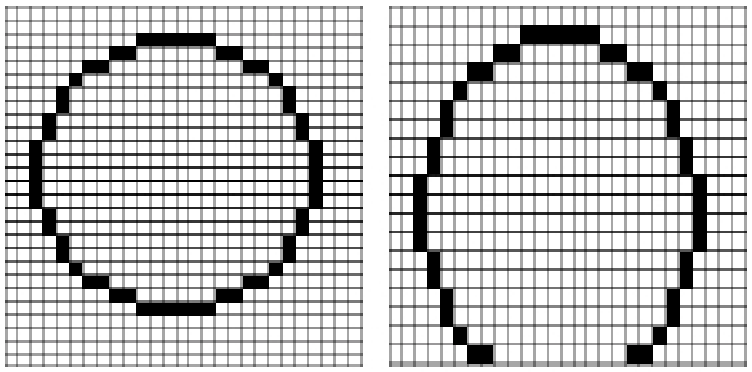


FIGURE 2-6 Aspect Ratio Examples

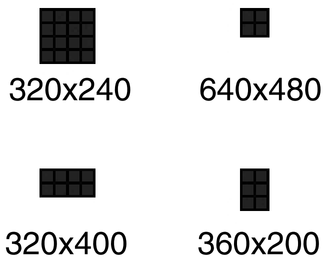


FIGURE 2-7: Pixel Shapes at Different Screen Resolutions

A display mode that has a 4:3 aspect ratio is considered to have a perfect aspect ratio. However, due to individual system hardware differences and how certain display modes are implemented on some machines, not all screen resolutions can produce perfect 4:3 aspect ratios. Therefore, the shapes drawn in these screen resolutions will appear somewhat distorted.

The significance of pixel shape should not be ignored! As pixels are essentially the building blocks for all graphics, you will find that many types of objects are more difficult to draw and accurately render with non-square pixels than with square pixels. In addition, pixel shape can contribute to the horizontal and vertical distortions some images exhibit when displayed in screen modes with imperfect 4:3 aspect ratios. Keep this in mind should you opt to use a screen resolution that supports non-square pixels.

NOTE: Several of the so-called Mode X, or non-standard, PC display modes use square pixels and have perfect aspect ratios.

Incidentally, you can determine the horizontal aspect ratio for a given display mode by dividing X by 4 (X/4) and Y by 4 (Y/4), where X is the horizontal screen resolution and Y is the vertical screen resolution. Then, simply divide the results.

For example, to determine the aspect ratio for a screen resolution 800x600 you would apply this formula as follows: 800/4 = 200 and 600/4 = 150. Dividing 200 by 150 yields 1.33 or a perfect 4:3 aspect ratio.

NOTE: Programmers sometimes equate the perfect 4:3 aspect ratio to a value of 1.0. According to this scale, those display modes that have aspect ratios that are more than 4:3 or less than 4:3 are considered to be greater than 1.0 and less than 1.0, respectively.

Table 2-4 shows some of the more common aspect ratios supported by different display modes (both Mode X and the standard, compatible modes).

TABLE 2-4: Common Display Mode Aspect Ratios

Screen Resolution	*Horizontal Aspect Ratio*	*Square Pixels*	*Display Mode Type*
320x200	1.6		Mode X
320x224	1.42		Mode X
320x240	1.33	✓	Mode X, Compatible
320x256	1.25		Mode X
320x400	.80		Mode X
320x480	.66		Mode X
360x200	1.8		Mode X
360x224	1.6		Mode X
360x240	1.5		Mode X
360x256	1.4	✓	Mode X
360x400	.90		Mode X
360x480	.75		Mode X
640x400	1.6		Mode X
640x480	1.33	✓	Compatible
800x600	1.33	✓	Compatible

Aspect Ratio Issues

If you've ever wondered why the shape and orientation of identical graphic images sometimes appear differently across systems, you can pretty much bet that aspect ratio is the reason. When a screen's aspect ratio is out of whack, so too will be everything else on the screen.

As such, you're likely to encounter these two problems related to aspect ratio when designing arcade game artwork for different display modes:

- Vertical compression
- Horizontal distortion

Vertical Compression

Graphics that were originally created on a screen that has a larger aspect ratio (i.e., 1.6) and then displayed on a screen with perfect 4:3 (1.33 horizontal) aspect ratio will appear vertically compressed or squashed. For example, this typically occurs when you draw your graphics at a resolution of 320x200 and then display them at a resolution of 320x240.

Horizontal Distortion

Graphics that were originally created on a screen that has a smaller horizontal aspect ratio (i.e., .80) and then displayed on a screen with perfect 4:3 (1.33) aspect ratio will appear horizontally distorted or stretched. For example, this occurs when you draw your graphics at a resolution of 320x400 and then display them at a resolution of 320x240.

In either case, you'll have graphic images that won't look right on-screen. Figure 2-8 illustrates these issues. Object A was created in a display mode with a perfect aspect ratio and square pixels. Object B shows the same image when vertically compressed as it's rendered in a display mode with an imperfect aspect ratio and pixels that are slightly wider than they are tall. Object C shows the same image when horizontally distorted as it's rendered in a display mode with an imperfect aspect ratio and pixels that are much wider than they are tall.

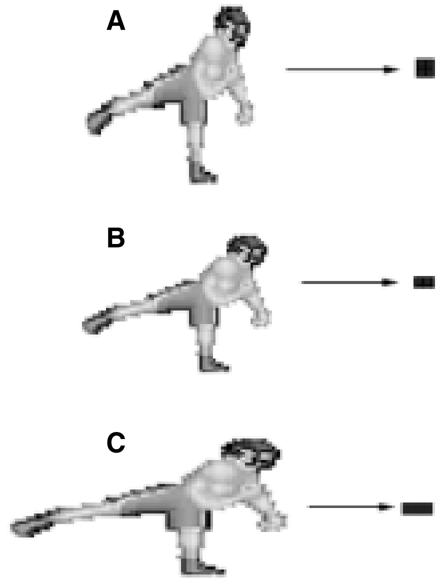


FIGURE 2-8: Example of Vertical Compression and Horizontal Distortion

What You Can Do

- You can minimize the impact of screen aspect ratio on your artwork by designing your graphics as closely as possible to the *target resolution* of your game. For our purposes, the target resolution refers to the resolution that the game will actually run in. For example, if you already know ahead of time (and you usually will) that the artwork for the DOS game you're working on will run in a resolution of 320x240, design your graphics at a screen resolution of 320x240 and not at 320x224 or 320x200, etc. This is just common sense.
- You can reduce aspect ratio distortion by avoiding designing your artwork in display modes that have horizontal aspect ratios that are less than 1.33. Such display modes have problems correctly displaying and maintaining the proportions of rectangular objects such as sprites and background tiles. If, for some reason, you must design for these display modes, try to use them for title and menu screens or for situations where proportion doesn't matter.
- Never try to save time by trying to adjust the aspect ratio of your artwork after the fact. By this I mean, don't draw your graphics in a resolution of 320x224 and then try to resize them down to match a screen resolution with a different aspect ratio, such as 320x200. The end results just won't look very good.

Refresh Rate

The *refresh rate*, also known as the frame rate, is a number that measures how fast the electron gun in a computer monitor's CRT (cathode-ray tube) paints an image from the top of the screen to the bottom. Refresh rates are measured in *hertz* (Hz), or cycles per second. For example, a display mode with a refresh rate of 60Hz repaints the display 60 times per second.

Why It's Important

The refresh rate affects how comfortable (or uncomfortable) it is to look at an image on a given screen. Obviously, you are more likely to be productive when you are comfortable than when you are not.

Refresh Rate Issues

- User Fatigue

User Fatigue

Regarding game graphics design, the refresh rate is important to mention for one reason only: user fatigue.

If the refresh rate of the display is too slow, the phosphors that compose the image will fade before the CRT can repaint them. This premature fading creates a phenomenon called *flicker*. Among other things, flicker can induce eyestrain and even headaches if you're exposed to it over a prolonged period of time.

Since creating game artwork and animation requires you to spend a significant amount of time in front of the computer screen, this isn't an ideal situation. Fortunately, you can minimize the effects of flicker by simply upping the screen's refresh rate. That's because higher refresh rates produce much less flicker.

VESA (`http://www.vesa.org`), an association of computer manufacturers that sets standards in the computer industry, recommends that users set their refresh rates to at least 85Hz because eyestrain and related discomfort can be drastically reduced at this level. Incidentally, this is a change from their old recommendation that had previously established 72Hz as the minimum satisfactory refresh rate.

Refresh rates are dependent on two factors: the capabilities of the computer's video hardware and the capabilities of the monitor. Therefore, not all systems or platforms will support the same refresh rate at the same resolution. In general, however, most new monitors come equipped to handle refresh rates of at least 72Hz and more than a few are capable of supporting refresh rates of 85Hz or more as well.

Table 2-5 shows some refresh rates that are typically supported at different display modes.

TABLE 2-5: Common Refresh Rates

Display Mode	*Common Refresh Rate(s)*
320x200	60Hz, 70Hz, 72Hz, 75Hz, 85Hz
320x224	60Hz
320x240	60Hz
320x400	60Hz, 70Hz
360x200	60Hz, 72Hz
360x240	60Hz
360x400	60Hz, 72Hz
360x480	60Hz
640x400	60Hz, 70Hz, 72Hz
640x480	60Hz, 72Hz, 75Hz, 85Hz, 120Hz
800x600	56Hz, 60Hz, 72Hz, 75Hz, 85Hz, 95Hz, 100Hz, 110Hz, 120Hz

NOTE: Refresh rates are sometimes influenced by external factors like electrical current. For example, it was common for home computers during the 1980s to have their screens refresh their contents at 60Hz in the United States but at 50Hz in Europe due to electrical differences between the two regions.

Table 2-6 shows some examples of different refresh rates and their impact on eyestrain after about three hours of continuous use.

TABLE 2-6: Refresh Rates and Impact on Eyestrain

Refresh Rate	*Likelihood of Eyestrain*	*Comments*
< 60Hz	Very High	Usually seen only on older computers.
60Hz-67Hz	High	Common refresh rate supported by many low-end computer monitors and televisions. The default Windows, DOS, Linux, and Macintosh refresh rates.
72Hz-75Hz	Moderate	Supported by most low-end computer monitors and video cards. Very common.
85Hz	Low	Supported by most midrange computer monitors and video cards. Increasingly common.
> 95Hz	Very Low	Supported only by high-end computer monitors and video cards. Still somewhat uncommon.

What You Can Do

To fight user fatigue, follow these suggestions:

- Don’t design your graphics on a screen that supports less than a 72Hz refresh rate, especially on larger monitors (i.e., those above 17") as they’re more prone to flicker problems than smaller monitors. Although 72Hz isn’t as good as 85Hz, it’s still a lot better than 60Hz. Of course, if your computer supports refresh rates of 85Hz or above, then take advantage of it. Your eyes will thank you.
- As it turns out, many operating systems default to lower refresh rates (i.e., 60Hz) even though they’re capable of supporting much higher ones. For example, Windows always defaults to 60Hz even if your system can support more. However, this situation can usually be corrected by simply adjusting your system’s display configuration, i.e., the Display Properties applet under the Windows Control Panel or the Monitors & Sound control panel on the Macintosh.
- It’s been scientifically proven that taking frequent breaks can reduce user fatigue. So, for every hour spent staring at a flickering CRT screen, try to spend at least 5-10 minutes looking away from the screen. Close and rest your eyes or simply focus on something else such as what’s out your window.

NOTE: DOS systems can't usually adjust their refresh rates unless a third-party utility is used, such as SciTech software's *Display Doctor* or the free *UniRefresh* utility that is included on the book's accompanying CD-ROM. See Appendix B for more information.

Table 2-7 shows the default refresh rates of the different computer platforms.

TABLE 2-7: Default System Refresh Rates

Platform	*Default Refresh Rate*
DOS	60Hz
Windows	60Hz
Macintosh	67Hz
Linux	60Hz or 67Hz*

* Depends on whether Linux is running on Intel or Macintosh hardware.

- Only use a high-quality computer monitor when designing your artwork since it's more likely to be able to handle the higher refresh rates you'll require than a cheaper, less capable monitor.

Color Capability

Everything around us is composed of color, including what we see on the computer screen. Arcade games, whether they're running on PCs or dedicated video game consoles, are capable of using and displaying an astounding range of colors. In fact, many people consider color use to be one of the most appealing aspects of arcade style games.

All computers understand color as a combination of three primary colors: red (R), green (G), and blue (B), or RGB. These combinations can be manipulated to create any of the millions of colors available in the color spectrum. The average computer display is capable of generating an almost unlimited number of colors. However, under most circumstances, it usually can't show them all at once. As it happens, the actual number of colors that can be displayed at any given time is dependent on the specific hardware capabilities of the system. For example, some machines can display hundreds, thousands, or even millions of simultaneous colors while others can only display a few. In order to compensate for this, the computer scientists developed the concept of the *color palette*. Color palettes are collections of colors from which one or more colors can be selected. Two types of color palettes exist: *physical palettes* and *logical palettes*.

Physical color palettes (also referred to as hardware palettes) contain all of the possible color values that can be generated by a computer's graphics hardware. In many cases, this can be as many as 16,777,216 colors, if not more. Logical palettes (also commonly referred to as color tables or just palettes), on the other hand, contain only a small portion of the colors that are present in a system's physical palette. They can be best thought of as "windows" into the actual hardware palette. Logical palettes are useful because they make it easy to organize and specify colors when designing graphic images.

The number of colors present in the logical palette is determined by the available *color depth*, or the number of data bits that make up each colored pixel in a given display mode.

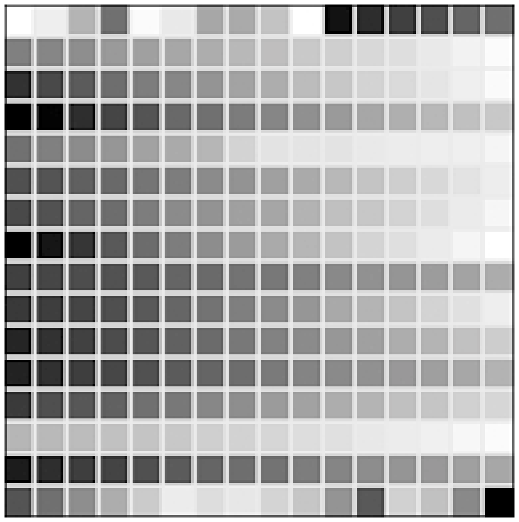


FIGURE 2-9: Logical Palette Example

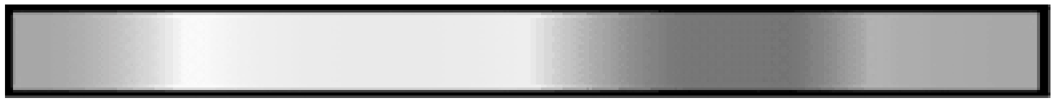


FIGURE 2-10: Physical Palette Example

Why It's Important

A system's color capability is important because it determines the extent to which you can add color to the images you create. Platforms with limited color capability present more design difficulties and challenges than those that support more extensive color capabilities, etc. These challenges can influence the aesthetics as well as the compatibility of your game artwork.

Refer to Table 2-8 for a list of possible color depth values and the number of colors each can display.

TABLE 2-8: Common Color Depths

Color Depth	*Number of Simultaneous Colors in Logical Palette*	*Common Name(s)*	*Comments*
1 bit/pixel	2	Monochrome, black & white	Previously used by older PCs and Macintoshes for arcade games. Obsolete.
2 bits/pixel	4	N/A	Previously used by older PCs for arcade games. Obsolete.
3 bits/pixel	8	N/A	Used by some older computers. Obsolete.
4 bits/pixel	16	Low color	Used by older computers and dedicated video console systems for arcade game graphics. Largely obsolete.
5 bits/pixel	32	N/A	Used by older computers and dedicated video console systems for arcade game graphics.
6 bits/pixel	64	N/A	Used by older computers and dedicated video console systems for arcade game graphics.
7 bits/pixel	128	N/A	Not used by any computer or video game system.
8 bits/pixel	256	Pseudocolor, Palette mode, indexed color, 8-bit color	Commonly used for arcade-style game graphics. Still very popular with many game developers.
15 bits/pixel	32,768	15-bit high color, thousands of colors	Some systems do not support 15-bit high color. Officially, neither Windows nor the Macintosh does. However, some third-party graphics cards support these modes and provide drivers, etc., on these platforms.
16 bits/pixel	65,536	16-bit high color, thousands of colors	Very common on modern Windows, Linux, and Macintosh systems. Used for a growing number of arcade-style games. Finally starting to replace 8-bit color for modern arcade games due to its higher color fidelity and performance advantages over the 24-bit modes.
24 bits/pixel	16,777,216	True color, millions of colors	Common on modern Windows, Linux, and Macintosh systems.

Logical palettes do not exist in display modes capable of supporting thousands or millions of colors (i.e., 16-bit or 24-bit color depths) as it becomes too difficult and unwieldy to specify colors in these modes.

NOTE: Technically, there is also such a thing as 32-bit true color but it's really just 24-bit true color with a special, 8-bit overlay mode. It's mainly useful for video compositing and for special 3D color effects and has only limited use for most 2D arcade game graphics.

Also, be sure to look at Table 2-9 for more information on the color capabilities supported by various computer platforms.

TABLE 2-9: Common Cross-platform Display Mode Color Capabilities

Platform Screen Resolution	*Supported Screen Resolution*	*Supported On-Screen Colors*
DOS Medium	320x200	16 or 256 (thousands or millions possible with VESA support)
DOS Mode X	320x240	256
DOS VGA	640x480	16 or 256 (thousands or millions possible with VESA support)
DOS SVGA	800x600	16 or 256 (thousands or millions possible with VESA support)
Linux Low	640x480	16, 256, thousands, millions
Linux Medium	800x600	16, 256, thousands, millions
Macintosh 14" Monitor	640x480	256, thousands, millions
Macintosh 15" Monitor	800x600	256, thousands, millions
Windows Low	320x200	256, thousands, millions
Windows Medium	640x480	16, 256, thousands, millions
Windows High	800x600	16, 256, thousands, millions

NOTE: The actual number of available colors supported by a particular display mode will depend on the physical capabilities and features of your graphics hardware.

Color Capability Issues

Given the fact that different systems have different color capabilities, it doesn't take a rocket scientist to realize how this might influence how you design your game artwork. Two issues that should be immediately considered are:

- Color vibrancy
- System capabilities

Color Vibrancy

In general, you'll find that images and games that display their graphics using thousands or millions of colors will look noticeably more vibrant and realistic than those that only use a few dozen or a few hundred colors. This is because these extra colors can make objects seem smoother and more defined due to the larger number of shades that are available.

Meanwhile, objects that are rendered using fewer colors will seem coarser and washed out in comparison. On such systems, you'll also need to spend a lot more of your time planning out the colors you'll want to use. In addition, you'll have to learn to make compromises between those objects that you want to render faithfully and those you don't. For example, you'll probably want to apply more color for the game's main character than for background images, etc.

For these reasons, it's advantageous to have more colors at your disposal to design with.

System Capabilities

Unfortunately, basic realities in the form of platform limitations prevent us from always being able to take advantage of such color-rich display modes. This is because a system's color capability is entirely dependent on the hardware it's running on. If the video hardware you're designing on or for doesn't support high or true color display modes, you're out of luck. Just as you can't get blood from a stone, you can't get high color from a system that can't physically support it.

What You Can Do

If you're not able to use a high color display mode in your game, you'll have to make the most of the situation. Here are a few ideas on how:

- You can simulate the presence of more color in an image through clever color selection and special shading tricks. As it turns out, certain color combinations, when used properly, can take advantage of how the average user perceives color so that less color can actually seem like more. We'll explore the issues of user color perception and color selection in more detail in Chapters 7 and 8.
- You can use a technique called *dithering* to simulate the presence of color. Dithering works by blending patterns of two colors to produce a third color much like you would when mixing paint. Through the careful blending of different colors and patterns, you can generate hundreds of additional shades. For example, a display mode that supports only 16 colors can usually generate up to 256 shades through dithering. Meanwhile, a screen with 256 colors can typically generate 65,536 shades and so on. Dithering is commonly used by systems to display images that contain more colors than they normally could display. For more information on dithering, consult Chapter 8.

- You can use high screen resolutions to trick the user into focusing more on the detail and composition of the image rather than its actual color. Images that are exquisitely detailed tend to minimize the need for color. Granted, this technique won't work for every situation, but it does work from time to time.
- You can take advantage of the fact that once a user starts playing a game, he or she tends to focus more on the game's action than on the specific details of the game's objects. This is especially true for most arcade games where fast action forces the user to keep his eyes trained on only small areas of the screen at any one time. This happens because most game objects usually move too fast for the player's eyes to be able to discern more than just passing details of object forms and shapes, etc.

Gamma Level

Gamma level is a measurement that describes the relationship between the color input from the computer's video hardware and how bright it appears on the monitor. The gamma level takes into account several elements of a system, including the tolerances of the CRT, that generate the picture in a computer monitor or TV and the overall color capabilities of the system.

A system's gamma level is usually indicated as a value on a scale between 1.0 and 3.0. As you move the scale towards a gamma level of 1.0, the colors on the screen appear lighter. Conversely, as you move the scale towards a gamma level of 3.0, the colors on the screen become darker.

Why It's Important

Gamma level is important because of how it can influence the appearance of your graphics images in different situation. For example, a properly set gamma level will produce true, realistic looking colors with good reproduction of the light, middle, and dark tones. An improperly adjusted gamma level won't.

Some systems, such as the Apple Macintosh and Silicon Graphics workstations, come with a properly tuned gamma level right out of the box. However, most DOS- and Windows-based PCs do not and will often need to adjust their gamma levels in order to correctly display color on the screen.

Gamma Level Issues

When designing your game graphics, you need to consider issues such as:

- Color accuracy
- Platform-specific gamma differences

Color Accuracy

Gamma level can directly affect an image's *color accuracy*, its overall ability to accurately reproduce color information on the screen. Consider, for example, an identical image of a solider shown on two systems with different gamma level settings. On one system, the soldier's uniform may appear correctly as khaki while on the other it may show up as brown. As you can appreciate, this issue presents a serious challenge to game graphics designers because they're never really able to determine how the colors they choose will look on different platforms unless they actually test them.

NOTE: Windows 3.1 is much worse at handling gamma levels than any of the other versions of Windows. Whenever possible, avoid creating your graphics on Windows 3.1. DOS also has no inherent ability to adjust its gamma level. Therefore, graphics designed in the DOS environment will definitely appear different (usually darker) than they will on another platform.

Platform-Specific Gamma Differences

Due to system gamma level differences, images will always appear much darker when viewed on a PC than they will on a Macintosh. This is because most PCs have gamma levels between 2.2 and 2.5 while all Macintoshes have a built-in gamma level setting of 1.8. In comparison, gamma levels on most video game consoles will usually be around 2.5, as they tend to use televisions rather than monitors for their displays. This is because virtually all televisions have a fixed gamma level of around 2.5.

The issue becomes even more complicated when you consider that gamma levels can vary even among machines on the same platform! For example, two Windows PCs might have their gamma levels set differently even if they use identical hardware and software.

Table 2-10 illustrates these system-specific gamma differences.

TABLE 2-10: Common Platform Screen Gamma Levels

Platform	*Approximate Gamma Level*	*Built-in Gamma Correction*
DOS	2.2-2.5	
Linux	1.8 or 2.2*	
Macintosh	1.8	✓
Windows	2.2-2.5	

* Depends on whether Linux runs on Intel or Macintosh hardware.

NOTE: The gamma levels mentioned in Table 2-10 are approximated because every system varies to some extent based on hardware quality and individual user adjustments.

What You Can Do

Unfortunately, there isn't too much you can do about rectifying this situation until the various computer hardware manufacturers standardize on a gamma level (there are actually proposals on the table that recommend the standard gamma level to be 2.2). In the interim, you can try:

- Using an image-processing program to manually adjust the gamma level for each platform on which you want to display your graphics. For example, if you created your artwork on a system with a gamma of 2.2 and you wanted to maintain the same gamma level on a machine with a gamma level of 1.8, you could use such a program to make this change. Fortunately, this is easy to do and a number of popular graphics programs provide this capability.
- Adding a gamma correction feature to your game. Such a mechanism will allow the user to manually adjust the gamma levels on their machines to suit their particular tastes and preferences. For example, if the game appears too dark, this option can be used to adjust the colors to something lighter and vice versa. Such options are now becoming standard features on today's modern computer games in order to compensate for platform specific gamma differences.
- Calibrating your computer's monitor using color-calibration software. Such software is usually bundled with your system. While this won't guarantee that the color in your artwork will display consistently across different platforms, it can help to ensure the colors you use in your images are at least created accurately in the first place.

It is not possible to compensate for gamma levels if you don't know your current gamma level setting. However, you can determine your system's current gamma level by displaying the image available on the book's accompanying CD-ROM in the `GAMMA` directory.

Choosing Display Modes to Design For

Every display mode has its own particular advantages and disadvantages. Deciding which display mode to design for isn't always an easy choice to make and it shouldn't be taken lightly. You need to weigh several important issues, including:

- Screen performance
- Image clarity
- Color capability

- System compatibility
- Audience hardware capabilities
- Programming support
- Graphics production time

Screen Performance

When it comes to fast-action arcade games, the issue of screen performance is still far and away the most important consideration when evaluating a display mode. While display modes with higher resolution and color capabilities will definitely enhance the quality of your artwork, they will almost always do so at the expense of drawing speed. This is due to the fact that higher screen resolutions and color modes will consume more of your system's resources (i.e., CPU time, RAM, and disk space) than lower resolutions and color modes will. There's simply more information for the computer to process, store, and manipulate, and hence, more raw computing power is needed to generate the display. As a result, higher resolution and higher color display modes will always display graphics somewhat slower than their lower resolution and color counterparts. So, while your images may look better when rendered in high resolutions and color display modes, other crucial items like playability may ultimately suffer in return for the improvement in aesthetic quality.

Therefore, when considering designing for any display mode you must factor in its performance. Consult with your developers to find the answer to the question: "Will using this particular display mode slow down the game?" If the answer is "yes," you might want to consider finding an alternative display mode.

There are several factors that can influence a particular display mode's screen performance. They include:

- Memory architecture
- Large screen objects
- High color displays
- Screen scrolling
- Programming

Certain display modes, namely the non-standard Mode X ones, offer programmers, and hence games, better performance than more traditional display modes due to their unique memory architecture. Therefore, using such screen modes can often give your games a needed speed boost, especially when performing complex animation.

Games that feature particularly large screen objects exacerbate the problem. This is due to the fact that larger screen objects take longer to draw and animate than smaller ones. Display modes that feature high resolutions and high color depths are particularly prone to this issue.

Games that display their graphics using lots of color (16-bit or above) can slow the screen display considerably. This is because such display modes require anywhere from two to four times more memory to be manipulated by the computer than those that use 16 or 256 colors. Avoid using such display modes unless they're absolutely necessary and make sure the target platform for your game is fast enough to handle the extra work required.

NOTE: This situation is especially true when it comes to DOS games since many DOS programming environments do not provide optimum video performance without resorting to custom display drivers and/or low-level access to the video hardware. It was also an important consideration with Windows 3.1 and 95 games until recently. Nowadays, most systems ship with very fast video hardware and the drivers for these devices are often pre-optimized for 16-bit color display modes rather than the 8-bit modes. Nevertheless, this is still an issue to think carefully about.

Screen scrolling, especially horizontal scrolling, can cause arcade games to experience major performance problems. This is because the computer must buffer and then move several copies of the current screen in order to produce these effects. While most video hardware is already set up to perform vertically oriented screen scrolling, horizontal scrolling is a different matter altogether. It typically requires special programming which consumes even more of the system's resources. Screen resolution and color depth can also impact screen-scrolling performance. Higher color, high resolution screens need more memory and CPU time to store and scroll the screen than lower color, lower resolution screens do.

Finally, how a game is programmed can have a significant impact on screen performance. While this is usually out of your control, as the game designer/artist, it's important for you to understand how a game is being written. You should know about any restrictions that the game's code imposes way ahead of time in order to avoid any problems later on.

For example, say the game's sprite engine requires that all sprites be 32 pixels wide. If you didn't find this out before you started drawing, you can easily wind up with hundreds of graphic objects that can't be used. So, if you're not sure about the details, ask someone! Close communication with the game's programmer(s) is key to preventing this and other mishaps during the course of the project. This way, you can do whatever you can in order to ensure that the graphics you create are properly optimized prior to their inclusion in the game.

Image Clarity

Image clarity is a subjective measurement that looks at the display mode's ability to show images with sufficient detail and definition. Screen resolution influences image clarity by allowing more information to be placed on the screen.

As a designer, you need to weigh the benefits that the different display modes offer you in terms of image clarity with that of the other factors mentioned here, particularly graphics production time and screen performance.

Color Capability

As discussed, an arcade game's color capabilities play an important role in the user's positive perception of the game. This being said, it's advantageous for us to use as much color as possible in our game artwork.

When possible, you should design your artwork in high color (16-bit and above) display modes, as they will give you the most freedom with regard to your color selections and the type of color effects you can create. However, low color (8-bit) display modes tend be the most practical choice for the widest range of arcade style games. They offer distinct performance (for the most part) and compatibility advantages over their higher color brethren. Therefore, you should carefully weigh your potential gains with your potential losses when choosing a display mode strictly on its color capability.

System Compatibility

Despite Windows' dominance in the market, designers should not underestimate compatibility with other systems and computer platforms when designing their artwork. This is particularly true with regard to the Macintosh and Linux platforms as they support similar if not identical graphics capabilities and represent a sizeable audience to boot.

By designing your artwork using cross-platform compatible display modes (i.e., non-proprietary), you have the opportunity to port your artwork to other platforms with a minimum of fuss and hassle.

Audience Hardware Capabilities

The actual hardware capabilities of your intended target audience can also be a determining factor regarding which display modes you choose. Many users have video hardware that supports certain screen resolution and color depths. Not all video hardware will support every display mode or display mode feature. This is usually due to limited available video memory. Video memory is used to hold the screen image. The amount of memory required to generate the image depends primarily on the current screen resolution and color depth being used. This formula calculates how much video memory each display mode requires:

```
Video Memory = ((X - Resolution) x (Y - Resolution) x Color Depth)
               ------------------------------------------------
                              (8 * 1,048,576)
```

Table 2-11 provides examples of the memory requirements needed by different display modes. This will often dictate the capabilities of your audience and ultimately the display mode you choose.

TABLE 2-11: Video Memory Requirements for Common Display Modes

Display Mode	320x200	640x480	800x600
4-bit (16 colors)	256 KB	256 KB	512 KB
8-bit (256 colors)	256 KB	512 KB	1 MB
16-bit (65,536 colors)	256 KB	1 MB	1 MB
24-bit (16.7 million colors)	256 KB	1 MB	2 MB

NOTE: It's important to point out that most video cards in modern systems ship with at least 4 MB of video memory. However, older cards, particularly lower-end cards manufactured in the last four to five years, usually only offer 1 or 2 MB of video memory.

NOTE: Of your potential audience, those users who are still running DOS, Windows 3.1, or pre-Power Macintosh systems are most likely to encounter issues with video memory.

Programming Support

Choosing a display mode isn't always a matter of aesthetics. Sometimes, you may find yourself designing for a given display mode due to its programming support.

Programming support, whether it's through a third-party graphics library or some operating system API, might make using a certain display mode attractive because it's simply easier to develop for when compared to another. Years ago, most game programming was done using custom, hand-coded assembly language routines. Today, however, such practices are often too difficult and time-consuming to implement. Some display modes are more widely documented and supported by programming tools than others. This means that programming considerations may ultimately make the choice of display modes for you.

Graphics Production Time

Unless you're working at your own pace, you'll eventually discover that game development is a very timely business. The market is very competitive and developers are always seeking to be the first out with the latest and greatest game. For example, at ZapSpot we release a new game every two weeks, no matter what. Creating a game's artwork and animation is no easy feat and next to programming the game itself, it's typically one of the longest parts of the game development process.

As such, you need to weigh how each display mode can affect the time you've been allotted to create your artwork for a given project. You'll find that some display modes, especially those with relatively low screen resolution and color capabilities, won't require as much of your time as display modes that support higher resolutions and more colors. So, in effect, your time requirements can make the choice for you.

Display Mode Selection Matrix

Table 2-12 summarizes the overall pros and cons to the various display modes discussed here. The information may help you gain more insight into which different display modes to choose.

TABLE 2-12: Display Mode Selection Matrix

Display Mode	*Image Clarity*	*Performance*	*Color Capability*	*System Compatibility*	*Programming Support*	*Graphics Production Time*
320x200	Low	Fast	16 or 256 (thousands or millions possible with VESA support)	DOS, Windows	Excellent at 16 or 256 colors but tends to be more limited at higher color depths.	Short
320x224	Low	Very Fast	256	DOS	Good	Short
320x240	Low	Very Fast	256	DOS	Excellent	Short
320x256	Low	Very Fast	256	DOS	Good	Short
320x400	Low	Very Fast	256	DOS	Good	Short
320x480	Low	Very Fast	256	DOS	Good	Short
360x200	Low	Very Fast	256	DOS	Good	Medium
360x224	Low	Very Fast	256	DOS	Good	Medium
360x240	Low	Very Fast	256	DOS	Good	Medium
360x256	Medium	Very Fast	256	DOS	Good	Medium

Display Mode	*Image Clarity*	*Performance*	*Color Capability*	*System Compatibility*	*Programming Support*	*Graphics Production Time*
360x400	Medium	Very Fast	256	DOS	Good	Medium
360x480	Medium	Very Fast	256	DOS	Good	Medium
640x400	Medium	Medium	256	DOS	Good	Long
640x480	High	Fast	16, 256, 32,768, 65,536, or 16,777,216	DOS, Windows, Linux, Macintosh	Excellent	Long
800x600	High	Medium	16, 256, 32,768, 65,536, or 16,777,216	DOS, Windows, Linux, Macintosh	Excellent	Long

NOTE: The number of simultaneous colors ultimately influences screen performance more than any other factor, including screen resolution.

Comprehensive Comparison of Display Mode Attributes

Table 2-13 provides a comprehensive comparison of the different display mode attributes offered by the most commonly used display modes on different computer platforms.

TABLE 2-13: Comprehensive Comparison of Display Mode Attributes

Platform Screen Resolution	*Supported Screen Resolution*	*Horizontal Aspect Ratio*	*Supported On-Screen Colors*	*Approximate Gamma Level*	*Common Refresh Rates*
DOS Medium	320x200	1.6	16 or 256 (thousands or millions possible with VESA support)	2.2-2.5	60Hz, 70Hz, 72Hz, 75Hz, 85Hz
DOS Mode X	320x224	1.4	256	2.2-2.5	51Hz, 60Hz
DOS Mode X	320x240	1.33	256	2.2-2.5	60Hz, 70Hz
DOS Mode X	320x256	1.25	256	2.2-2.5	58Hz
DOS Mode X	320x400	.80	256	2.2-2.5	60Hz, 70Hz
DOS Mode X	320x480	.66	256	2.2-2.5	60Hz, 70Hz
DOS Mode X	360x200	1.8	256	2.2-2.5	72Hz
DOS Mode X	360x224	1.6	256	2.2-2.5	51Hz
DOS Mode X	360x240	1.5	256	2.2-2.5	61Hz
DOS Mode X	360x256	1.4	256	2.2-2.5	57Hz

Platform Screen Resolution	*Supported Screen Resolution*	*Horizontal Aspect Ratio*	*Supported On-Screen Colors*	*Approximate Gamma Level*	*Common Refresh Rates*
DOS Mode X	360x400	.90	256	2.2-2.5	72Hz
DOS Mode X	360x480	.75	256	2.2-2.5	61Hz
DOS Mode X	640x400	1.6	256	2.2-2.5	70Hz, 72Hz
DOS VGA	640x480	1.33	16 or 256 (thousands or millions possible with VESA support)	2.2-2.5	60Hz, 70Hz, 72Hz, 75Hz, 85Hz
DOS SVGA	800x600	1.33	16 or 256 (thousands or millions possible with VESA support)	2.2-2.5	56Hz, 60Hz, 70Hz, 72Hz, 75Hz, 85Hz
Linux Low	640x480	1.33	16, 256, thousands, millions	2.2	60Hz, 70Hz, 72Hz, 75Hz, 85Hz
Linux Medium	800x600	1.33	256, thousands, millions	2.2	60Hz, 70Hz, 72Hz, 75Hz, 85Hz
Macintosh 14" Monitor	640x480	1.33	256, thousands, millions	1.8	67Hz, 72Hz, 75Hz, 85Hz, 95Hz, 100Hz, 120Hz
Macintosh 15" Monitor	800x600	1.33	256, thousands, millions	1.8	67Hz, 72Hz, 75Hz, 85Hz, 95Hz, 100Hz, 120Hz
Windows Low	320x240	1.33	256, thousands, millions	2.2-2.5	72Hz
Windows Medium	640x480	1.33	16, 256, thousands, millions	2.2-2.5	60Hz, 70Hz, 72Hz, 75Hz, 85Hz, 95Hz, 110Hz, 120Hz
Windows SVGA	800x600	1.33	16, 256, thousands, millions	2.2-2.5	60Hz, 70Hz, 72Hz, 75Hz, 85Hz, 95Hz, 100Hz, 120Hz

NOTE: Performance rating is a fairly subjective measurement as different systems and hardware configurations tend to drastically influence these results. Both the Windows and Linux results assume optimized graphics drivers are being used. The examples given in Table 2-13 are taken from my own experiences. Your own conclusions and mileage may vary from mine.

NOTE: Apple Macintosh systems only recently standardized on 800x600 display modes. Prior to the mid-1990s, the Macintosh series actually used a screen resolution of 832x624. However, though a sizeable number of Macintosh systems still support this display mode, it's so close to 800x600 that any differences from the designer's standpoint are negligible.

Specific Display Mode Recommendations

Table 2-14 summarizes my display mode recommendations.

TABLE 2-14: Recommendations for Compatible Display Modes

Category	320x200/Mode X Display Modes	640x480 Display Modes	800x600 Display Modes
Image clarity and performance	Use when performance requirements supersede image clarity.	Use when you want to emphasize a game's image clarity over its performance.	Use when your game requires the best possible image clarity and when performance is important but a secondary concern.
Platform compatibility	Generally recommended for DOS games or when you need to maintain compatibility with video game consoles, etc.	Generally recommended only for designing graphics for Windows, Linux, or Macintosh games.	Use only when designing graphics for Windows, Linux, or Macintosh games.
Graphics development time	Use when designing and graphics production time is limited.	Use when you have more time available to do graphics design and production.	Use when you have more time available to do graphics design and production.

NOTE: Although I recommend designing your artwork in a 640x480 display mode, there's really no significant penalty if you choose to do so at 800x600. Besides offering more screen area to work with, 800x600 display modes share the same screen aspect ratios as the 640x480 display modes. So, if designing in a 800x600 display mode is more comfortable for you, please do so. I use 800x600 extensively for all of the game artwork I design.

Display Mode and Arcade Game Sub-Genre Recommendations

The final assessment of a display mode is its usefulness in rendering the graphics for the different types of arcade games. Table 2-15 summarizes which display modes work best with which games. Please use this table as a rough, general guide. Due to technical limitations, you'll often find that some display modes work better for certain types of games than others do.

TABLE 2-15: Display Modes and Arcade Game Recommendation Matrix

Platform	*Display Mode*	*Color Support*	*Recommended Game Type(s)*
DOS	320x200	16, 256	Puzzlers
DOS	320x240	256	Pong games, shooters, maze/chase games, puzzlers, and platform scrollers
DOS	640x480	256	Pong games, shooters, maze/chase games, puzzlers, and platform scrollers
Windows*	320x240	256	Shooters, maze/chase games, puzzlers, and platform scrollers
Windows	640x480	256, thousands	Pong games, shooters, maze/chase games, puzzlers, and platform scrollers
Windows	800x600	256, thousands	Pong games, puzzlers, and platform scrollers
Linux	640x480	256, thousands	Pong games, shooters, maze/chase games, puzzlers, and platform scrollers
Linux	800x600	256, thousands	Pong games, puzzlers, and platform scrollers
Macintosh	640x480	256, thousands	Pong games, shooters, maze/chase games, puzzlers, and platform scrollers
Macintosh	800x600	256, thousands	Pong games, puzzlers, and platform scrollers

* Denotes not compatible with Windows 3.1.

Arcade Game Type Recommendation Explanations

- **Pong games**—Pong games work well across all display modes due to the fact that they don't usually have more than a dozen or so objects on-screen at any one time. In addition, these games do not usually scroll the screen. As previously mentioned, screen scrolling can place a major drain on arcade game performance.
- **Puzzlers**—Puzzlers work great across all display modes and platforms because they don't require a significant amount of the computer's resources. Such games feature minimal animation and often no scrolling.
- **Maze/chase games**—Maze/chase games work well on most display modes. Because they can display many simultaneous on-screen objects and can employ scrolling, they aren't usually suited for high resolutions such as

800x600 and above. However, they are pretty safe for most other resolutions with few, if any, performance related problems.

- **Shooters**—Like maze/chase games, shooters work well on most display modes. However, as they tend to make extensive use of screen scrolling and can display dozens, if not hundreds, of on-screen objects, they shouldn't be used on resolutions above 640x480 except on fast machines.
- **Platform scrollers**—Platform scrollers are the most sophisticated and resource-intensive of all arcade-style games. They make extensive use of horizontal (and often vertical) scrolling and often display large, complex objects and backgrounds. As a result, they are largely unsuitable for display modes with resolutions above 640x480 except on relatively fast machines.

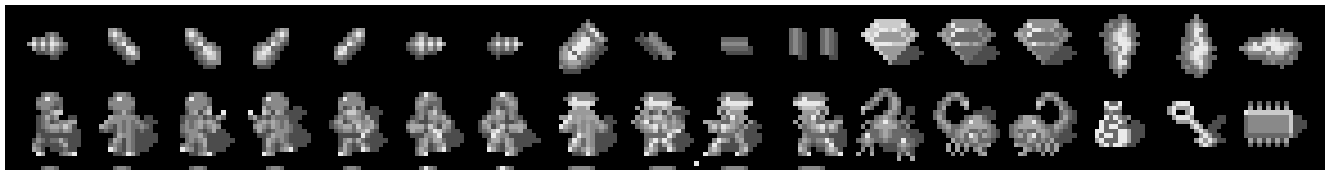
Rules for Display Mode Selection

As you have seen, choosing a display mode for which to design your artwork and animation can be a difficult and often complex process. There are many issues to consider and weigh. To help make the selection process somewhat easier, try following these rules:

- **Check with your programmer**—Always check with your programmer or programming team. When it comes to technical matters, whether you're talking about the development environment, platform capabilities, or programming tools, the programmer usually knows best. Make sure that you discuss your thoughts on the matter with them and get their input before you start drawing anything. As they're the ones who will have to make your graphics actually work in a game, they're in the best position to tell you what can and can't be done in a given display mode as well as disclose any other related technical issues you may face. When in doubt about some technical issue, never guess or make assumptions. Play it safe and consult a programmer.
- **Consider the target platform(s)**—Always consider the capabilities of the target platform for your game. Different systems have different capabilities. You need to look at these and determine if the target platform can handle what you have in mind. When in doubt, go for the lowest common denominator. For example, although 16- and 24-bit color is supported by a large number of computers, all machines support 256 colors. If you're not sure about what percentage of your audience has hardware capable of supporting more than 256 colors, then stick with 256 colors.
- **Factor in your color requirements**—Take a good look at the color requirements of your game and the particular color capabilities of each display mode that is available to you. Be sure to evaluate issues such as whether or not a given display mode can effectively support the number of colors your game is likely to need. When in doubt, go for the next highest display mode. For

example, if you're designing an arcade game and think that you'll need to use more than 256 colors, go for a display mode that supports 65,536.

- **Factor in your image quality requirements**—Each arcade game has different resolution requirements. Some require the maximum detail possible while others can get away with a relatively low screen resolution. Therefore, you need to evaluate the specific resolution needs of your game and determine the most suitable display mode from that. You should also carefully examine the aspect ratio of each display mode. Will designing your graphics in a display mode with unusual aspect ratios create any problems for you? If so, consider using a different display mode. When in doubt, choose a screen resolution that is common across several platforms (as described in Table 2-3) as one or more of these will provide adequate image fidelity, cross-platform compatibility, and reasonable screen performance.



Chapter 3

Image Compression and Graphic File Formats

In this chapter, you'll learn about:

- **Common image compression schemes**
- **Essential graphic file formats**
- **Important graphic file formats**
- **File format suitability for arcade game graphics**
- **Caveats for working with graphic files**
- **Specific graphic file format recommendations**

Image Compression

Graphic images can consume a lot of disk space, particularly when they're saved at high screen resolutions and/or color depths. To see what I mean, let's calculate the file size required by images saved at common screen resolutions and color depths by applying this simple formula:

```
                   H x V x C
File Size (KB) = --------------
                   8 x 1024

H represents the number of horizontal pixels
V represents the number of vertical pixels
C represents the color depth
```

TABLE 3-1: Examples of Different Graphic Image File Sizes

Screen Resolution	*Color Depth*	*File Size (in KB)*
320x200	4 bits/pixel	32
320x200	8 bits/pixel	64
320x240	8 bits/pixel	75
640x480	4 bits/pixel	150
640x480	8 bits/pixel	300
640x480	16 bits/pixel	600
640x480	24 bits/pixel	900
800x600	8 bits/pixel	468.75
800x600	16 bits/pixel	937.5
800x600	24 bits/pixel	1406.25

As you can see from Table 3-1, graphics files, particularly those at higher screen resolutions and color depths, can grow to be quite large. When designing arcade game graphics, you can easily wind up with dozens, if not hundreds, of such files. Even with today's multi-gigabyte hard drives, storing them can consume a fair amount of disk space. What's more, large graphics files tend to be more difficult to work with than smaller ones as they take longer to load, save, and manipulate than their smaller counterparts. Need to put a bunch on a floppy? Forget about it. Want to e-mail one to a friend in New Zealand? Don't even bother unless you both have access to ISDN, DSL, or cable modems.

To make more efficient use of available disk space, most graphics files are *compressed*. Compression makes use of complex mathematical equations to dramatically reduce the sizes of images. There are several methods of image compression available, however, they all tend to fall into two broad categories: *lossless compression* and *lossy compression*.

Lossless Compression

Lossless compression technologies involve no data loss. The original information of each file is stored intact and can be completely recovered from its compressed state at the time it is decompressed or extracted. Lossless compression is usually implemented using one of two different methods: *statistical* or *dictionary-based*.

The statistical method uses a three-step process to do its dirty work. First it reads in a single byte of data. Next, it calculates the probability of that byte's appearance in the data. Finally, it encodes the byte by replacing it with a symbolic token that acts as a kind of shorthand version of the data. When the data is later decoded, the symbol is replaced with the original byte. The statistical method can achieve very high compression levels if the data contains many repeating values.

The dictionary-based method uses a somewhat different concept. It reads in several bytes of data and looks for groups of symbols that appear in a dictionary. If a match is found, a pointer into the dictionary is made. The more matches found in the image data, the higher the level of compression that can be achieved.

Lossless compression is important to us because it maintains the *integrity*, or the quality, of the file's information.

There are several lossless compression algorithms commonly used on graphic images. These include:

- RLE compression
- Packbits compression
- LZ77 compression
- LZW compression

RLE Compression

Run-length encoding, or RLE, compression works on images by analyzing their graphic data sequentially from left to right and top to bottom. It compares the value of each byte of information with the value of the previous byte. Each new data value is recorded into a "packet" of two bytes where the first byte contains the number of times the value is repeated, and the second packet contains the actual value. The bytes in the packet are known as the "run count" and "run value," respectively.

In situations where a graphic image contains many repeat values, the compression ratio will be very high. For example, if every byte in a 1000-byte image was identical, its size could be reduced to 20 bytes, giving it a 50:1 compression ratio. An image with lots of different values won't compress very well, and in some cases can actually become larger than the original. For example, if all bytes in an image are different from each other, the image's size will double, because two bytes are used to store each byte in the image.

RLE compression exists in several forms, all of which work essentially the same way but differ somewhat in terms of efficiency. Because it works well for most types of images, RLE is the most common lossless image compression technology and is used by such popular graphics formats as PCX and BMP.

Packbits Compression

Packbits is considered an RLE compression scheme because it also looks for "runs," or repeated values, and calculates their number, or overall "length." The repeated bytes it finds are then "packed" together, hence the name. Compared to RLE, images that use packbits typically offer superior compression rates. Yet despite this, packbits compression is used by only a few file formats, namely by LBM and TGA.

LZ77 Compression

LZ77 (Lempel, Ziv, 77) compression was developed in 1977. It works by keeping track of the last *n* bytes of the data seen, and when it encounters a data sequence that has already been analyzed, it records its position along with the length of the sequence.

LZ77 is used as the primary compression scheme for the PNG image format. In addition, all popular file compression schemes, such as ARJ, LHA, ZIP, and ZOO, are based on the LZ77 algorithm.

LZW Compression

The LZW (Lempel, Ziv, Welsh) compression scheme does its work by looking for patterns of data and assigning codes to them. It works best on images with large areas of solid colors. Images that contain many different colors and patterns aren't very good candidates for this type of compression.

LZW is a "dictionary-based" compression technology. Its "dictionary" includes a special table that contains a code for each possible value contained in an image. For example, if the LZW compression is used on an 8-bit image, the LZW dictionary will be initialized with codes for up to 256 possible values. As the image data is read, new values are added to the table as each unique pattern of data is found. LZW dictionaries aren't actually saved along with the compressed data. Instead, the dictionary is reconstructed as part of the image decompression process.

LZW is most often associated with GIF (Graphics Interchange Format) image files. However, it is used for other types of graphics files, including TIFF (Tagged

Image File Format), and the basic technology serves as the foundation for many of the ZIP file compression algorithms.

Lossy Compression

Lossy compression techniques all involve some sort of information loss. Data that is compressed using a lossy compression scheme usually can't be restored back to its original, uncompressed state. However, in exchange for this inaccurate reconstruction, lossy compression is capable of achieving very high compression rates.

NOTE: When using a lossy compression scheme, repeatedly saving an image will cause that image's quality to degrade.

There are two lossy compression methods in general use. These are:

- Color reduction
- JPEG

Color Reduction

Color reduction is a special process that allows you to create files with fewer colors than contained in the original image. For example, you can reduce a 24-bit (with millions of colors) image down to an 8-bit (256 colors) one. The end result will produce a new file that is substantially smaller than the original, as indicated by Table 3-1. Whenever you reduce the number of colors in an image, there is always some image information that is lost.

There are a couple of color reduction techniques in use. The most basic form is called *remapping*. This simply means that when an image is color reduced, the resulting image will have the best color reproduction possible. Every pixel contained in it will be replaced with colors available in the new palette. Unfortunately, the results from remapping are usually less than satisfactory.

The other color reduction process is called *color dithering*. Color dithering works much like mixing two shades of paint to produce a third color. Instead of mixing paint, however, it blends patterns of different colors to simulate the presence of colors not in the current palette. As a result, color dithering can usually produce better results than remapping, especially when reducing an image from 256 colors down to 16. Most graphics programs support both methods of color reduction, although the resulting image quality varies widely between them.

The primary advantage of color reduction is that it's relatively fast and usually produces good results on most types of images. Color reduction is almost always used in conjunction with one of the lossless compression techniques to reduce image file size even further. Both color reduction and dithering are discussed in more detail in Chapter 8.

JPEG

JPEG is a lossy compression technique that is used for compressing photo-realistic images with millions of colors in them. For more information on JPEG and how it works, see the JPEG entry under the Important Graphic File Formats section of this chapter.

Figure 3-1 compares the two compression schemes. Notice the artifacting exhibited by lossy compression compared to lossless compression.

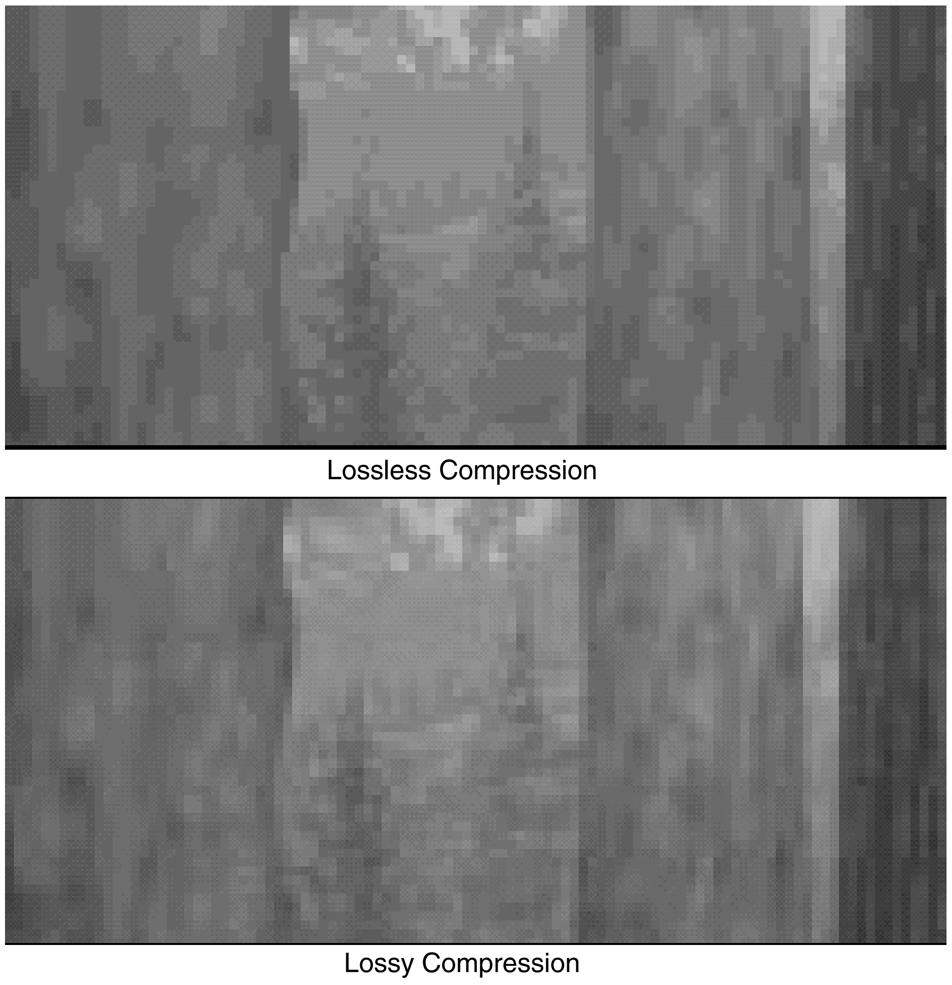


FIGURE 3-1: Lossless vs. Lossy Compression Comparison

Essential Graphic File Formats

Computers use file formats to negotiate the exchange of information between different applications and systems. Graphics are no different in this regard. Once you spend time designing game artwork, you'll want to save what you create for future editing or display. Many graphics editors offer several choices of file formats to save your pictures in. However, only a few are actually useful to arcade game graphics designers. I've taken the liberty of identifying and describing them here.

BMP (Bitmap)

Native Platform(s): Windows 3.1, 95, 98, NT 4.0, and 2000

File Extension(s): .BMP, .bmp

BMP is the standard graphics format used by the various incarnations of Microsoft's Windows operating systems (i.e., Windows 3.1, 95, 98, and NT). The BMP format comes in two flavors, RGB and RLE.

The BMP RGB format, as its name implies, saves images as RGB data (red, green, blue) which is a representation of what's actually generated on the computer's display. This allows you to accurately save and exchange images with thousands or millions of colors in them. The RGB format doesn't support image compression.

The BMP RLE format stores image data using one of the RLE compression schemes. Unlike the BMP RGB format, this allows you to take advantage of compression and substantially reduce the overall size of your graphic images. Besides compression, the main difference between the BMP RGB and BMP RLE formats is that the BMP RLE format is limited to saving images with a maximum of 256 colors.

The Windows BMP format is definitely one of the best choices when it comes to saving your game graphics, especially on the Windows platform. This is simply due to the fact that virtually every Windows graphics package can read and write BMP files. In addition, the BMP format enjoys a good level of cross-platform compatibility, as Apple *QuickTime* (versions 2.0 and better) and most major Macintosh graphics packages have the ability to read and write both BMP format variations.

NOTE: Although BMP is the standard Windows graphics file format, some Windows graphics programs still don't support RLE flavored BMP files. To avoid any unpleasant compatibility problems down the road, make sure all of the graphics software you use works with BMP RLE files. Otherwise, just to be safe, always save your files in the BMP RGB format.

TABLE 3-2: BMP Characteristics

BMP Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
RGB	Any	No	No	1, 4, 8, or 24 bits	Windows, Macintosh*
RLE	Any	Yes, RLE	No	1, 4, 8, or 24 bits	Windows, Macintosh*

* Compatible with *QuickTime* and most popular graphics packages.

NOTE: Windows also supports two related image formats called *DIB*, or device-independent bitmap, and *RLE*, or run-length encoding (simply an RLE compressed DIB file with an .RLE file extension). While a number of graphics packages can read and write these formats, there are still plenty of graphics programs that won't. Therefore, I generally don't recommend using these formats unless you know your graphics software can actually support them.

GIF (Graphics Interchange Format)

Native Platform(s): N/A

File Extension(s): .GIF, .gif

The GIF format was developed by the CompuServe Information Service during the mid-1980s as a means to pass graphic files between different computers. Until GIF was developed, graphic formats were usually limited to being used on the same types of machines. Since that time, the format has evolved and has established itself as a universal graphics standard.

There are two versions of the GIF format in use: *87a* and *89a*. GIF 87a was the original implementation of the format. Although still used, it has been largely replaced by the later 89a format. Technically speaking, there is little difference between the two, although the 89a format does offer some additional features. These include interlacing, the ability to store multiple images within a single image, and transparency. *Interlacing* enables images to appear in stages while they load. Multiple frames can be used to produce simple, frame-based animation effects. These images are frequently referred to as *animated GIFs*. *Transparency* allows the background of an image to show through, making it seem as if an image is free-floating. Neither version of the format can be used to store images with more than 256 colors.

Animated GIF files are particularly interesting to the arcade game artist. They are essentially compiled sequences of images and are frequently used in online games as game sprites. In fact, I used them to create all of my game animations for my work at ZapSpot. However, be careful when using them in your own game projects because once you create an animated GIF image, it's very difficult to extract the individual frames of such animations for additional editing and manipulation. Therefore, animated GIFs can best be thought of as a non-reusable image format.

NOTE: While both versions of the format are widely used, some older graphics programs don't know how to deal with GIF 89a files. Therefore, if you opt to store your images in the GIF format, always try to save your images as GIF 87a to ensure maximum compatibility with different applications and platforms.

By definition, files stored in the GIF format are always compressed. Yet, unlike most of the other formats described here, they utilize the LZW compression scheme. This puts them at a slight advantage over other formats as images compressed using LZW generally offer better compression ratios, especially when used on images that contain large areas of similar colors.

The GIF format has seen widespread use on the Internet and World Wide Web where it has become the graphics format of choice. Yet, surprisingly, it hasn't seen much use in game development, despite being perfectly suited for the role. Due to its near universal popularity, virtually all graphics packages support the GIF format. In fact, it's probably one of the safest and reliable methods for exchanging graphics between different computers and operating systems.

One potential problem with using GIF files to store your game graphics is how some graphics programs will optimize the color palette. While this has no adverse effect on how the image actually appears on-screen, it can cause problems when you try to edit the file later as the image colors won't be arranged in exactly the same order as when you first created the file. What's more, due to the optimization, many of the colors of the image's original color palette will actually be removed. This situation is particularly true of graphics packages that emphasize GIF use for the World Wide Web. Make sure your software doesn't do this by testing it with non-critical files before you start using the GIF format to store your important artwork. To be safe, consider saving your images as GIF only once they are finalized or simply use a different file format to store your images altogether.

NOTE: Since 1994, there have been major legal issues involved with the LZW compression scheme used by the GIF format. The Unisys Corporation owns the patents to the technology and now requires any vendor which develops software that uses the GIF format to acquire an expensive license. This situation may serve to reduce the popularity of GIF in future generations of graphics software.

NOTE: As the GIF format is one of the most universal of all graphic formats, it's also a natural choice for storing graphics for cross-platform, Java-based arcade games.

TABLE 3-3: GIF Characteristics

GIF Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
GIF 87a	Any	Yes	No	1, 2, 3, 4, 5, 6, 7, or 8 bits	DOS, Macintosh, Windows, Linux, Java
GIF 89a	Any	Yes	No	1, 2, 3, 4, 5, 6, 7, or 8 bits	DOS, Macintosh, Windows, Linux, Java

IFF (Interchange File Format)

Native Platform(s): Commodore Amiga, Atari ST, DOS

File Extension(s): .IFF, .iff, .LBM, .lbm

The IFF format originated on the Commodore Amiga around 1985. It was developed by Electronic Arts for use with their powerful *Deluxe Paint* graphics package. The format's versatility quickly made it a standard on that platform. Later, the IFF format made its debut on both DOS (c. 1988) and the Atari ST (c. 1990) when versions of the *Deluxe Paint* program were released for these systems.

There are two versions of the IFF format still in everyday use: IFF and LBM. The basic IFF format is compatible with several different systems including the Amiga, Atari ST, and the PC. The LBM format, on the other hand, is native to PC and its version of the *Deluxe Paint* program. LBM is actually a subset of the IFF format called PBM. However, any graphics program compatible with IFF files can usually handle LBM files and vice versa.

Both IFF formats support compressed and uncompressed images. When dealing with compressed images, IFF usually employs RLE compression, while LBM files usually use packbits compression.

It's been my experience that some programs have problems reading LBM files created with the PC version of *Deluxe Paint* and vice versa. This is probably due to the fact that Electronic Arts never officially documented how the LBM packbits compression was actually implemented in their software. Therefore, there's a wide degree of variation in how different programs interpret and write these files. Because of this, my advice is to not use LBM for your images. Rather, use the PCX format instead. Given this issue, it's surprising to find that *Deluxe Paint* has no problems with the IFF files generated by other programs.

TABLE 3-4: IFF Characteristics

IFF Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
IFF	Any	Yes, RLE	No	1, 4, 5, 6, 8, or 24 bits	Atari ST, Amiga, DOS, Windows*, Macintosh*
LBM	Any	Yes, packbits	No	1, 4, or 8 bits	DOS

* Denotes limited compatibility, usually obtained through graphic conversion software.

PCX

Native Platform(s): DOS

File Extension(s): .PCX, .pcx

The PCX format has been around for a long time. ZSoft developed it in the mid-1980s for its popular *PC Paintbrush*. Because of its longevity, PCX is almost as ubiquitous as the GIF format and is even more widely supported. Even so, PCX is most at home on DOS systems where over the years it has established itself as the de facto graphics standard for that platform.

The PCX format is quite flexible and can store images with color depths of 1, 2, 4, 8, and even 24 bits. PCX files also use an RLE compression scheme, which makes PCX the recommended file format for any DOS related game and graphics development. However, because BMP is the Windows standard graphics format, I suggest that you use BMP instead of PCX when working with Windows applications if you have a choice. At this time, PCX enjoys only limited support on the Macintosh platform. Although most of the major Macintosh graphics packages can read and write the format, *QuickTime* doesn't currently support it, thus limiting its overall compatibility on that platform.

NOTE: Several versions of the PCX graphics format (i.e., version 1, 3, and 5) actually exist. However, versions below 5 are seriously outdated and do not support color depths greater than 4 bits. Therefore, I have opted not to discuss them here.

Even with the PCX format's widespread popularity, it's far from perfect. While the format is well documented, it isn't always well implemented. I've observed various discrepancies with how different programs interpret and display PCX files. Despite this issue, PCX is a good alternative to BMP, especially when working with programs or development environments that don't support the BMP format.

PCX can actually be considered an unofficial Windows graphics format because it's supported by the *MS Paint* application bundled with every version of Windows since version 3.1. Incidentally, *MS Paint* is actually a stripped-down version of the *PC Paintbrush* program.

TABLE 3-5: PCX Characteristics

PCX Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
Version 5	Any	Yes, RLE	No	1, 2, 4, 8, or 24 bits	DOS, Windows, Macintosh*

* Denotes limited compatibility, usually obtained through graphic conversion software.

PICT (Picture)

Native Platform(s): Apple Macintosh

File Extension(s): .PICT, .pict, .PCT, .pct

Apple developed the PICT file format way back in 1984, when it introduced the original Macintosh computer. PICT is the standard graphics format used by Macintosh computers. Because the format is internal to the Macintosh's operating system, it can be assumed that all Macintosh graphics programs can read and/or write legally generated PICT files without any problems.

There have been two major versions of the PICT format introduced, PICT 1 and PICT 2. PICT 1 was the original version of the format. It supported images that contained up to eight colors and has long been considered obsolete. PICT 2 was introduced several years after PICT 1. It's the current version of the format and is capable of supporting images that contain as many as 16,777,216 colors. A few minor variations of the format exist, however, these are largely proprietary to certain applications and are rarely used otherwise.

The PICT format is interesting in that it's capable of storing both vector and bitmap data within the same file. However, the vast majority of the images saved in the PICT format are actually just straight bitmaps. As with most of the formats described here, PICT utilizes a form of RLE compression in order to keep images reasonably small and compact when stored on disk.

NOTE: If a Macintosh user has *QuickTime* 2.0 or better installed on his or her machine, it's possible to save PICT files using whatever compression library *QuickTime* supports, including JPEG.

NOTE: PICT files are viewable through the Windows desktop if there's a version of *QuickTime* 2.5 or better installed.

TABLE 3-6: PICT Characteristics

PICT Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
PICT 2	Any	Yes, RLE or *QuickTime*	No	1, 4, 8, 24, or 32 bits+	Macintosh, Windows*

* Denotes limited compatibility, usually obtained through graphic conversion software. The Windows version of *QuickTime* allows them to be viewable, however.

+ A color depth of 32 bits is actually 24 bits with an 8-bit alpha channel used to store transparency information.

Important Graphic File Formats

The graphic file formats mentioned in this part of the chapter impose some sort of limitation on your artwork, either in terms of overall system/application compatibility or image quality. This does not mean they are useless, however. They all have some use or potential use in game graphics development and it's more than likely that you'll come across one or more of them in your projects.

FLIC

Native Platform(s): DOS

File Extension(s): .FLI, .fli, .FLC, .flc

Programmer Jim Kent (author of *Autodesk Animator* for DOS and *Aegis Animator* for the Atari ST) developed the original FLIC file format in 1993 as an attempt to create a standard animation playback format. Since that time, the format has seen widespread use by DOS game developers.

There are two variations of the FLIC format in use: FLI and FLIC. FLI files are the older of the two and are limited to animations with a 320x200 resolution. The later and more common FLIC format supports several additional features and extensions. Animations in both versions are limited to a maximum of 4,000 frames.

All FLIC files are capable of displaying up to 256 colors per frame of animation and can utilize a variety of compression algorithms including RLE and packbits.

The FLIC format was a widely used predecessor of the Windows AVI movie format and is still commonly used in game development circles. However, as an animation format, FLIC files are best suited for large animations such as those featured in game title sequences or cut scenes. For smaller animations, other formats such as animated GIFs are a better choice.

NOTE: FLI files limit their color values to VGA 0-63 levels or a maximum of 64 shades per color. The FLIC format was later modified to accommodate SVGA 0-255 color values or a maximum of 256 shades per color. Please refer to Chapter 9 for more information on the specific implications of these differences.

TABLE 3-7: FLI/FLIC Characteristics

FLIC Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
FLI	Limited to a maximum of 320x200	Yes, RLE	No	8 bit (color)	DOS, Windows*
FLIC	320x200, 640x480, 800x600	Yes, RLE, packbits	No	8 bit (color) or 16+ or 24 bit+	DOS, Windows*

* Denotes limited compatibility, usually obtained through graphic conversion software.
+ Not part of the official file format but supported by extended variations of the format.

JPEG (Joint Photographic Experts Group)

Native Platform(s): N/A

File Extension(s): .JPG, .jpg

JPEG is an image compression mechanism and not a file format in itself. There are actually several classes of JPEG compression but the most popular is known as JFIF. However, in everyday use, the terms JPEG and JFIF are synonymous.

JPEG uses a lossy compression scheme that is designed to take advantage of the limitations of the human eye. Any image detail that is not visually perceived by the eye is lost when stored as a JPEG. As a result, JPEG is capable of providing images with incredible compression ratios, usually anywhere between 5:1 and 15:1. JPEG is also unique among the compression techniques mentioned here because it allows you to trade off image quality to gain more compression. The higher the level of compression, the lower the quality of the image and vice versa. The most common side effect of using JPEG compression is that images often display noticeable artifacting and blurring. JPEG works best on highly detailed images, such as photographs, as these types of images have more content to lose. Also, any image that uses JPEG compression is automatically promoted to 24-bit color depth, even if it was originally created at a lower color depth.

In addition to JFIF, there are two other variations of JPEG compression, progressive JFIF and lossless JFIF. Progressive JFIF (also called progressive JPEG) stores an image in overlapping layers. When a progressive JFIF image loads, it displays its content in stages. Each layer appears gradually until the whole image is rendered. This makes progressive JFIF useful for displaying large images in situations where bandwidth might be low, i.e., over the Internet or on slow computers. Lossless JFIF stores images without using lossy compression. Therefore, images stored this way do not suffer from the visual problems traditionally associated with JPEG compression. Yet, at the same time, lossless JFIF images also don't enjoy the high image compression rates offered by standard JFIF.

Using JPEG compression for arcade game graphics is generally not a good idea. First, it's lousy for artwork that contains sharp details (which are commonly found in sprites and menu screens) since the colors of different objects tend to bleed into each other. Second, it promotes all images to 24 bit regardless of their original color depth, making them useless for palette-based images. And, finally, images stored as JPEGs can't be resaved without further degrading their image quality. This makes it nearly impossible to edit them without destroying the integrity of the original image.

TABLE 3-8: JPEG Characteristics

JPEG Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
JFIF	Any	Yes, JPEG	Yes	8 bit (grayscale) or 24 bits	DOS, Macintosh, Windows, Linux, Java
Progressive JFIF	Any	Yes, JPEG	Yes	8 bit (grayscale) or 24 bits	DOS, Macintosh, Windows, Linux, Java
Lossless JFIF	Any	No	No	8 bit (grayscale) or 24 bits	DOS, Macintosh, Windows, Linux, Java

PNG

Native Platform(s): N/A

File Extension(s): .PNG, .png

The PNG format evolved out of the ashes of the 1994 Unisys patent dispute over the LZW compression used in the GIF format when Thomas Boutell (along with others) developed the PNG format specification as an alternative and eventual replacement for the GIF format. Although until recently support for PNG has been slow in coming, it's now on the verge of becoming a new standard as more and more graphics tools are being updated to support it.

Like GIF files, PNG files support interlacing and transparency information (up to 254 levels). However, the PNG format also introduces several improvements over GIF and the other file formats mentioned here. These include built-in gamma correction, support for 8-bit color, 8-bit grayscale, true color images, and built-in file integrity checking. PNG's internal gamma correction ensures that graphic images saved as PNG files will retain a consistent gamma level regardless of the platform on which they're displayed. Its ability to store both 8-bit and 24-bit images makes it extremely useful for game-oriented graphics. Finally, its built-in file integrity checking will help minimize problems with file corruption and the like.

The PNG format uses the LZ77 compression algorithm that gives it better compression ratios than many of the other file formats discussed here.

TABLE 3-9: PNG Characteristics

PNG Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
PNG	Any	Yes, ZIP	No	8-bit color, 8-bit grayscale, or 24 bits	DOS, Macintosh, Windows, Linux, Java

PSD (Photoshop)

Native Platform(s): Macintosh, Windows 3.1, 95, 98, NT 4.0, and 2000

File Extension(s): .PSD, .psd

The PSD format is the native file format used by Adobe's *Photoshop* program. It can store images with up to 24-bit color, and the current version supports features such as layers and transparency. PSD files can be either uncompressed or compressed using RLE compression.

Although *Photoshop* enjoys an extremely large following among Web, multimedia, and game developers worldwide, it's also an expensive program. This fact means that few low-end graphics packages are currently compatible with the PSD format. Therefore, unless you have specific need to use it, it is recommended that you avoid saving your images in PSD format.

TABLE 3-10: PSD Characteristics

PSD Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
PSD 5.0	Any	Yes, RLE	No	8 or 24 bits	Macintosh, Windows
PSD 3.0	Any	Yes, RLE	No	8 or 24 bits	Macintosh, Windows, Linux+
PSD 2.0/2.5	Any	Yes, RLE	No	8 or 24 bits	Macintosh*, Windows*

* Denotes limited compatibility, usually obtained through graphic conversion software.
+ Linux systems can read PSD files when using the free *GIMP* image editor software that is frequently bundled with many Linux installations.

NOTE: Most of the applications outside of *Photoshop* that support the PSD file format are only compatible with the older, PSD 2.0/2.5 variations. PSD versions below 2.5 don't support layers or transparency information. Also, PSD 5.0 files store text as editable layers. This information might be lost when loading such files into older versions of *Photoshop* or other applications. Keep these issues in mind when exchanging files with applications that claim PSD compatibility.

PSP (Paint Shop Pro)

Native Platform(s): Windows 3.1, 95, 98, NT 4.0, and 2000

File Extension(s): .PSP, .psp

PSP is the native file format of Jasc's popular *Paint Shop Pro* program. As with most of the file formats described here, the PSP format can store graphics images at a variety of color depths, including 24-bit color.

The PSP format can also store images in either compressed or uncompressed form. Compressed PSP images use either RLE or LZ77 (a variation of LZW) compression schemes. Version 5 of the PSP format introduced the ability to store *Photoshop*-like layer and transparency information with images as well.

Although *Paint Shop Pro* enjoys a sizeable following among many Windows users, few other graphics programs are actually compatible with the PSP format. Therefore, it's not recommended that you save your images as PSP files unless you intend to work exclusively with that program.

TABLE 3-11: PSP Characteristics

PSP Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
PSP 3.0/4.0	Any	Yes, RLE or LZ77	No	8 or 24 bits	Windows*
PSP 5.0/6.0	Any	Yes, RLE or LZ77	No	8 or 24 bits	Windows*

* Denotes limited compatibility, usually obtained through graphic conversion software.

NOTE: Older versions of *Paintshop Pro* aren't fully compatible with the newer versions of the PSP format.

TGA (Targa)

Native Platform(s): N/A

File Extension(s): .TGA, .tga

Truevision, Inc. (now Pinnacle) originally developed the Targa format in 1985 to use with its line of professional video capture products. However, since that time, the TGA format has seen many refinements and considerable use as an output format for many high-end painting and 3D programs.

TGA files can contain 8, 16, 24, or 32 bits of color information per pixel and can store images using a number of compression schemes including RLE and LZW. Although a technically solid graphics format, TGA's lack of support among many lower-end graphics applications makes it difficult to recommend for your graphics projects.

TABLE 3-12: TGA Characteristics

TGA Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
N/A	Any	No	No	8, 16, 24, or 32 bits	DOS, Macintosh*, Windows*
N/A	Any	Yes, RLE, packbits, and LZW	No	8, 16, 24, or 32 bits	DOS, Macintosh*, Windows*

* Denotes limited compatibility, usually obtained through graphic conversion software.

TIFF (Tagged Image File Format)

The Tagged Image File Format, or TIFF as it is commonly known, was designed with the intention of becoming the standard graphics file format. As such, it was engineered from the start to handle virtually any contingency that one might encounter. This provides TIFF files with the flexibility to support monochrome and color images as well as several methods of compression including packbits and LZW.

Despite the good intentions of TIFF's designers, the format's flexibility has actually encouraged application developers to develop variations of the format that don't entirely stick to the published format specification. As a result, no single application can now claim universal TIFF compatibility and there will always be some version of the format that will cause problems with different graphics software.

Although TIFF is capable of storing almost any kind of graphic image, it's most commonly associated with multi-megabyte high-resolution scanned images.

TABLE 3-13: TIFF Characteristics

TIFF Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
TIFF	Any	Yes, LZW, packbits	No	2, 4, 8, 16, or 24 bits	DOS, Macintosh, Windows, Linux, Java

XPM (X PixMap)

Native Platform(s): UNIX, Linux

File Extension(s): .XPM, .xpm

XPM is the de facto graphics standard for the X Window system running on UNIX and Linux computers. They are generated by a variety of applications including *Xpaint* and *GIMP*. XPM files can contain monochrome and color images. They are most frequently used to store icon data for X Window systems.

Unlike the other formats described in this chapter, XPM files do not use compression. Instead, images are saved as ASCII, C language source files. While this makes them versatile and easy to transmit through e-mail, images stored in the XPM format tend to be extremely large when compared to other graphic file formats.

Unfortunately, very few graphics packages outside the UNIX and Linux platforms can correctly handle XPM format files. This makes them difficult to exchange between other platforms.

TABLE 3-14: XPM Characteristics

XPM Variant	*Screen Resolutions*	*Compression*	*Lossy*	*Color Depths Supported*	*Platform Compatibility*
XPM	Any	No	No	2, 4, 8, 16, or 24 bits	Linux, UNIX

File Format Suitability for Arcade Game Graphics

Table 3-15 summarizes the overall suitability of each of the graphic file formats discussed here for storing various types of game related objects.

TABLE 3-15: File Format Suitability for Arcade Game Artwork

File Format	*Title Screens*	*Menu Screens*	*Sprites*	*Backgrounds*
BMP	✓	✓	✓	✓
GIF	✓	✓	✓	✓
IFF/LBM	✓	✓	✓	✓
JPEG	✓			✓
PCX	✓	✓	✓	✓
PICT	✓	✓	✓	✓
PNG	✓	✓	✓	✓
PSD	✓	✓	✓	✓
PSP	✓	✓	✓	✓
TGA	✓	✓	✓	✓
TIFF	✓	✓	✓	✓
XPM	✓	✓		

NOTE: Neither the PSD nor PSP can be directly used in game graphics. They typically need to be "flattened" or optimized to discard extra information such as layers and transparency data.

NOTE: I left any mention of the FLI/FLIC format out of this table because it's primarily an animation format and not a general-purpose graphics file format. As such, it really isn't up to storing the static images required for game development. However, it is a useful animation playback format.

Figures 3-2 through 3-4 provide examples of the different types of arcade game artwork covered in Table 3-15.

Table 3-16 summarizes the overall suitability of the different graphic file formats described throughout this chapter.

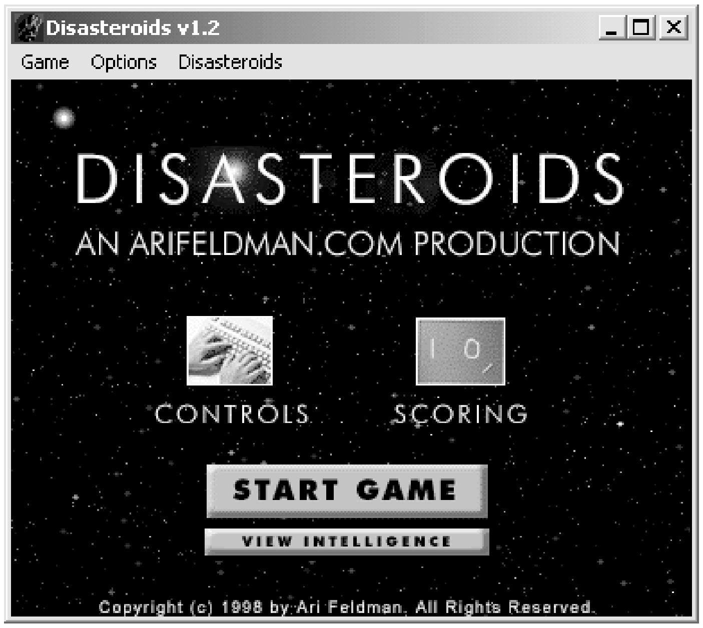

Disasteroids v1.2
Game Options Disasteroids
DISASTEROIDS
AN ARIFELDMAN.COM PRODUCTION
CONTROLS
SCORING
START GAME
VIEW INTELLIGENCE
Copyright (c) 1998 by Ari Feldman. All Rights Reserved.

FIGURE 3-2: Title/Menu Screen Example

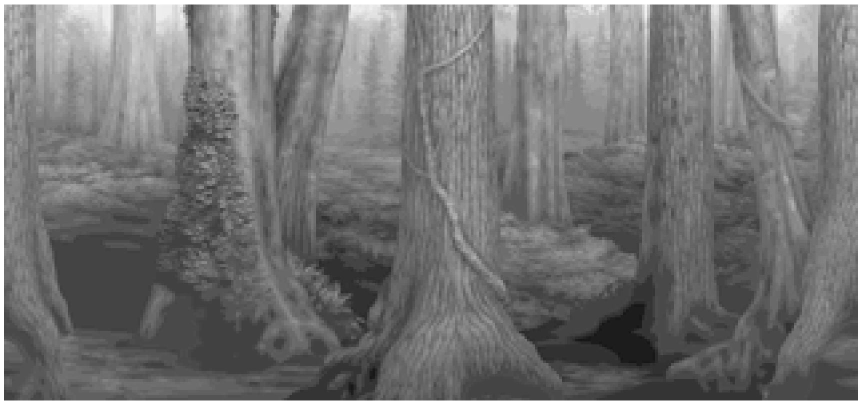


FIGURE 3-3: Background Screen Example

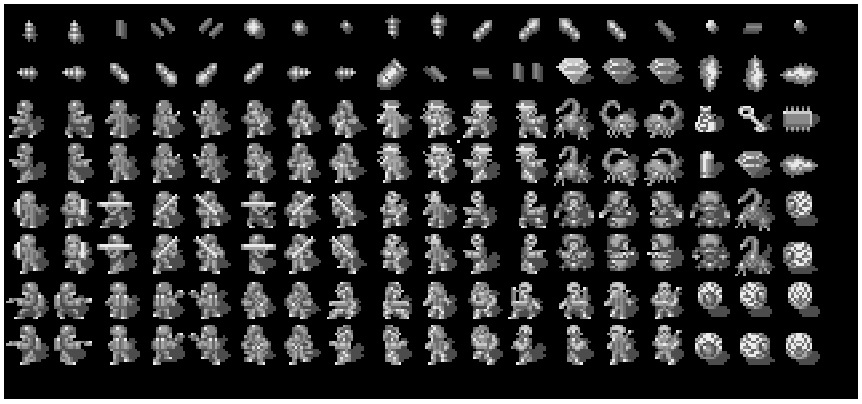


FIGURE 3-4: Sprite Screen Example

TABLE 3-16: File Format Suitability Comments

File Format	*Comments*
BMP	■ The standard graphics file format for all versions of Windows. ■ A good choice for exchanging graphics files between Windows and the Macintosh (provided that a version of QuickTime is installed on the Macintosh). ■ Not recommended for use with DOS, as very few DOS applications can read or write this format.
FLI/FLIC	■ The best overall animation file format to use with DOS systems. ■ Can be used with Windows as long as you're sure your software is compatible with it. Fortunately, a fair number of Windows graphics packages are. ■ Definitely not recommended for the Macintosh due to extremely limited compatibility with software on that platform.
GIF	■ The safest overall graphics format for reliably exchanging files between DOS, Windows, Macintosh, and Java. ■ The best overall graphics format for storing game objects for Java-based games.
IFF/LBM	■ The best format to exchange graphics files between the Amiga, Atari ST, and DOS systems should you need to. ■ Generally not recommended for use on Windows unless you commonly work with programs that you know support it. ■ Has very limited support on the Macintosh and is not recommended for use on that platform.
JPEG	■ Offers extremely high image compression rates; however, there's a trade-off between image quality and the level of compression. ■ Offers excellent compression for photographic images but generally not for game-oriented artwork. ■ Potentially useful for game title screens if they contain photo-realistic details.
PCX	■ The best overall graphics format to use with DOS systems. Widely considered the de facto DOS graphics standard. ■ Not recommended for use with Windows unless you commonly work with programs that you know support it. However, it's the best format to use if you commonly find yourself exchanging files between the Windows and DOS platforms. ■ Has relatively limited support on the Macintosh and is not recommended for use on that platform except to exchange files with DOS systems.
PICT	■ The standard graphics format on the Macintosh platform. As such, compatibility is assumed to be universal between Macintosh graphics applications. ■ Not recommended for use with DOS, as very few DOS graphics programs are compatible with it. ■ Has very limited use on Windows systems except to exchange graphics files with Macintosh systems.

File Format	*Comments*
PNG	■ Not currently recommended for use in DOS, Windows, or Macintosh game development due to limited support among graphics tools and development tools at this time. However, this situation is expected to change in the very near future. ■ Potentially a very good file format for Java-based games.
PSD	■ Offers good compatibility between higher-end Macintosh and Windows graphics applications. ■ Not recommend for DOS systems due to extremely limited support on that platform.
PSP	■ Not recommended for exchanging files on DOS or Macintosh systems due to nonexistent application support on these platforms. ■ Offers only limited support among Windows graphics applications. Watch out!
TGA	■ Not recommended for use with DOS, Windows, or the Macintosh unless you commonly work with programs that you know will support it. Usually, only expensive, high-end video and 3D animation programs do.
TIFF	■ Although compatible with all major platforms, due to all of the format variations that exist, it is not a very reliable format for exchanging files between different systems.
XPM	■ Only recommended for Linux and UNIX systems. Do not use it to exchange files with other platforms due to spotty compatibility with applications on other platforms. ■ Offers no compression so XPM files are excessively large, making it less than ideal for game-oriented artwork.

File Format Compression Savings

Tables 3-17 and 3-18 show how the various formats described here compare with each other when compressing different types of images. For testing purposes, I compressed two sample images that represent the two extremes: a photo-realistic title screen/menu screen and a typical arcade game sprite screen with large areas of flat color. Both images were originally saved as 640x480 Windows RGB BMP files and had file sizes of 900 KB each. I then calculated the results and indicated the file compression savings as both KB and percentages.

TABLE 3-17: File Format Compression Savings—Title Screen/Menu Screen

File Format (compression)	*Final Image Characteristics*	*Original File Size*	*Compressed File Size*	*Total Savings*
BMP (RLE)	640x480, 8 bits/pixel	900 KB	348 KB	552 KB (61%)
GIF (LZW)	640x480, 8 bits/pixel	900 KB	168 KB	732 KB (81%)
IFF/LBM (RLE)	640x480, 8 bits/pixel	900 KB	216 KB	684 KB (76%)

File Format (compression)	*Final Image Characteristics*	*Original File Size*	*Compressed File Size*	*Total Savings*
JPEG (JFIF at 66% quality)	640x480, 24 bits/pixel	900 KB	116 KB	784 KB (87%)
PCX (RLE)	640x480, 8 bits/pixel	900 KB	284 KB	616 KB (68%)
PICT (RLE)	640x480, 8 bits/pixel	900 KB	312 KB	588 KB (65%)
PNG (LZ77)	640x480, 8 bits/pixel	900 KB	160 KB	740 KB (82%)
PSD (RLE)	640x480, 8 bits/pixel	900 KB	308 KB	592 KB (65%)
PSP (LZW)	640x480, 8 bits/pixel	900 KB	168 KB	732 KB (81%)
TGA (RLE)	640x480, 8 bits/pixel	900 KB	320 KB	580 KB (64%)
TIFF (LZW)	640x480, 8 bits/pixel	900 KB	168 KB	732 KB (81%)
XPM (ASCII)	640x480, 8 bits/pixel	900 KB	680 KB	220 KB (24%)

TABLE 3-18: Format Compression Savings—Sprite Screen

File Format (compression)	*Final Image Characteristics*	*Original File Size*	*Compressed File Size*	*Total Savings*
BMP (RLE)	640x480, 8 bits/pixel	900 KB	124 KB	776 KB (86%)
GIF (LZW)	640x480, 8 bits/pixel	900 KB	84 KB	816 KB (90%)
IFF/LBM (RLE)	640x480, 8 bits/pixel	900 KB	212 KB	688 KB (76%)
JPEG (JFIF at 66% quality)	640x480, 24 bits/pixel	900 KB	100 KB	800 KB (89%)
PCX (RLE)	640x480, 8 bits/pixel	900 KB	120 KB	780 KB (87%)
PICT (RLE)	640x480, 8 bits/pixel	900 KB	128 KB	772 KB (85%)
PNG (LZ77)	640x480, 8 bits/pixel	900 KB	76 KB	824 KB (92%)
PSD (RLE)	640x480, 8 bits/pixel	900 KB	128 KB	772 KB (85%)
PSP (LZW)	640x480, 8 bits/pixel	900 KB	84 KB	816 KB (90%)
TGA (RLE)	640x480, 8 bits/pixel	900 KB	124 KB	776 KB (86%)
TIFF (LZW)	640x480, 8 bits/pixel	900 KB	84 KB	816 KB (90%)
XPM (ASCII)	640x480, 8 bits/pixel	900 KB	356 KB	544 KB (60%)

NOTE: I didn't make any mention of the FLI/FLIC format in Tables 3-17 and 3-18 because it's primarily an animation format and not a general-purpose graphics file format. Mentioning it here would be like comparing apples and oranges.

Overall, the results fell into line with my expectations but added a few surprises as well. Not surprisingly, JPEG offered the best compression rate on the photo-realistic title screen, averaging a staggering 87% compression saving. The LZ77-based PNG format produced the second highest savings with 82%. The

LZW-based file formats such as GIF, PSP, and TIFF followed close behind, averaging 81%. Meanwhile, RLE-based file formats such as BMP, IFF, PICT, PCX, PSD, and TGA all pulled up the rear, averaging only a 66.5% reduction in file size. What was interesting was the fact that the LZW compression schemes yielded identical savings while the RLE compression schemes seemed to vary quite a bit in the savings they offered.

However, the results were a lot closer when it came to dealing with the flat color sprite screen. Here, the PNG format yielded the highest compression rate at 92%. GIF, PSP, TGA, and TIFF followed right behind, averaging 90%. And this time, the other formats weren't too far apart, averaging 84%. This time, JPEG produced a file with an 89% compression saving, but the image's quality was dramatically and negatively affected.

NOTE: Different graphics software will produce different results. This is because some programs offer better file compression logic than others do. As a result, your compression savings may very well differ from my findings.

Despite these impressive numbers, don't fall into the trap of using a particular graphic file format just because it offers a great compression rate. A file format is only as good as the program that can read it. Unless you have special or unusual needs, you should always consider a file format's compatibility with different systems and applications over its ability to compress files.

Caveats for Working with Graphic File Formats

Although we use them every day and they have proven a reliable mechanism for exchanging data between machines, graphics files are still imperfect. Things can sometimes go wrong. The two most common problems are:

- File corruption
- Incompatible versions

File Corruption

Compression schemes do their work by essentially scrambling and rearranging the contents of a file. The vast majority of the time they work well and the compressed file decompresses without any problems or glitches. However, every now and then, you may come across a file that gets corrupted while being compressed and/or saved.

File corruption can rear its ugly head for any number of reasons. For instance, there might be a bug in how a certain program implemented a particular file-compression routine or a system crash might have caused the file save process to abort before all of the pertinent information was written to disk.

Therefore, in order to minimize the likelihood of this happening in the future, I recommend that you always save at least two versions of every important graphics file you create. Also, avoid making changes to important files while in an unstable environment. In other words, don't continue to work on your file if your system or graphics program is about to crash. You're only asking for problems. In addition, I strongly suggest that you follow the advice I give in Chapter 4 and regularly back up your files.

Incompatible Versions

A number of the file formats mentioned here can be used across different computer platforms with little or no additional manipulation. However, occasionally you will encounter a graphics file that should import correctly into a certain program and just doesn't. Often, the file isn't corrupt, but rather, you've discovered an unpleasant side effect of progress: incompatible file format versions.

Yes, that's right. As software packages evolve and improve, they often introduce new file formats and don't always retain 100% backward compatibility with older versions of their file formats. The problem is compounded by the fact that many third-party software vendors are slow to update their software to reflect these changes. As a result, it's entirely possible for you to save your files in a particular version of a file format that one program supports and another doesn't!

The best and easiest way to cope with this problem is to simply pay attention when saving or exporting your images. Often, the software you're using will provide one or more save options. Among other things, these options will allow you to determine the version that your file is saved as. In addition, most graphics programs will inform you when you've chosen an outdated or obscure version of a file format that might cause compatibility problems with other software. Heed its advice.

Just to drill the point home, here are some examples of common graphic file formats that might cause you grief and some solutions on how to deal with them:

- **BMP**—Always save using the RGB subformat. This ensures universal compatibility with different applications, as RLE compression isn't supported by all BMP-compatible software.
- **GIF**—Choose 87a as it is supported by all GIF-compatible software, especially when using older software.
- **IFF/LBM**—Always save the file as compressed (RLE or packbits). Some programs will allow you to save uncompressed IFF/LBM files but many programs aren't compatible with them.

- **PCX**—Always choose version 5 unless you plan to use your files with 14-year-old software or want to lose most of your artwork's color information!
- **PSD**—Choose version 2.0 or 2.5 if you're not using layers.
- **TIFF**—Always choose uncompressed or LZW. Also, be sure to indicate the appropriate *byte order*, Intel or Motorola, in order to suit the target platform for the file. Doing both of these things can greatly reduce the compatibility issues associated with this particular file format.

Graphic File Format Recommendations

Unfortunately, I can't recommend one all-inclusive file format simply because everyone has his or her own unique requirements. Therefore, in order for you to determine the best file format(s) to use, you should look closely at such game development related issues as:

- Graphics applications
- Development environment
- Artwork type
- Operating systems and platform

Graphics Applications

The graphics applications you use can have a major influence on which format you ultimately select. Ask yourself these simple questions: What file formats are the graphics programs I use compatible with? Can they read or write files in the formats I need? What programs will I eventually use? Weigh your answers and choose a file format accordingly.

NOTE: Don't decide these issues solely on compatibility with your preferred graphics applications. As you'll see in Chapter 4, there's an entire class of image conversion software that can convert graphics files from one format to another. In fact, to make things easier for you, I've included some of the better programs of this type on the book's accompanying CD-ROM. You can find more information by referencing Appendix B of this book.

Development Environment

Your development environment can also have a significant influence on which format you eventually decide to go with. For example, your favorite C graphics library might only work with PCX files while another might work with all popular file formats. The last thing you want is a hard drive of image files that won't work with your favorite development tools. Therefore, you need to find out what file format restrictions your particular development environment places on you and then select the appropriate format.

Generally speaking, I've found that:

- Multimedia authoring tools such as Macromedia's *Director* and the Clickteam's *The Games Factory* tend to offer the best built-in support for graphic file formats.
- Visual programming languages such as Delphi and Visual Basic tend to offer support for different graphic formats via third-party controls, components, and DLLs. However, they will typically also support at least one or more common graphic formats internally as well.
- Character-oriented languages such as C, Assembler, and Pascal tend to offer the poorest native support and often need one or more external graphics libraries to provide the appropriate compatibility with the different file formats discussed in this chapter.

Artwork Type

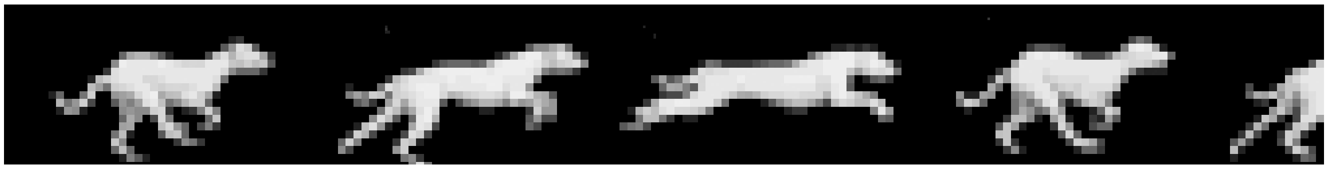
The type of artwork you're designing can also play an important role in the selection process. As you saw in Tables 3-15 and 3-16, certain file formats work better on some types of graphics files than others. You need to take this into account and consider your available options accordingly. For example, if you're designing game sprites, you'll definitely want to use a lossless compression format rather than a lossy one so you can preserve the original integrity of your artwork. Similarly, if you are working with photo-realistic artwork, a file format that offers good compression and that better supports 24-bit images may be the way to go.

Operating System and Platform

The need to remain compatible with different computer platforms and operating systems also impacts your decision. For example, if you're trying to port the game you're working on to the Macintosh, then PICT might be a good solution. Alternatively, if you need to maintain compatibility with your favorite DOS graphics editor, BMP might not be the best choice. Ultimately, the choice is an easy one to make as long as you think about your needs and requirements logically and then weigh your options carefully. Refer to Table 3-19 for suggestions on which file formats to use on which platforms.

TABLE 3-19: Recommended File Format by Platform

File Format	*DOS*	*Windows 3.1, 95, 98, NT 4.0, and 2000*	*Macintosh*	*Linux*	*Java*
BMP	✓	✓		✓	
FLI/FLIC	✓	✓			
GIF 87a/89a	✓	✓	✓	✓	✓
IFF/LBM	✓	✓			
JPEG	✓		✓	✓	✓
PCX	✓	✓		✓	
PICT			✓		
PNG	✓	✓	✓	✓	✓
PSD		✓	✓		
PSP		✓			
TGA	✓	✓	✓	✓	
TIFF	✓	✓	✓	✓	✓
XPM				✓	



Chapter 4

Files and File Management

In this chapter, you'll learn about:

- **File naming conventions**
- **Exchanging files across platforms**
- **File backups and file backup strategies**
- **Version control**
- **Basic asset management**

This chapter discusses several important but often-ignored topics of game graphics development: how to name, exchange, back up, maintain, and manage the files you create. Without understanding these issues and why they're necessary, your projects will suffer. However, if you take the time to appreciate them and apply what you learn here into your daily routine, your projects will go smoother and faster, and the work that you produce will be of higher quality. Sound good? Great, then read on.

File Naming Conventions

Once you determine the best graphic file format to store your game graphics in, you should start thinking about how to actually name the files you create. If you don't do this, you'll soon find yourself with lots of files on your hard drive and absolutely no idea of what they are or what they contain. Establishing a good file naming convention early on in your projects is a good practice and will definitely save you time and frustration later on.

However, before you start naming all of your files a certain way, you should make sure that you fully understand the various limitations imposed by your particular operating system as well as any operating system with which you're likely to exchange files. Unfortunately, DOS, Windows 95/98/NT/2000, Linux, and the Macintosh all have somewhat different rules for how they go about naming files. You need to know what these differences are if you plan on working with and exchanging files between these platforms.

DOS and Windows 3.1 File Naming Rules

- Both DOS and Windows 3.1 use what is known as an "8.3" file naming scheme. This includes eight alphanumeric characters, a dot, and then three more characters to hold the file's extension. This gives you a grand total of eleven characters to use for filenames or folders, which in the grand scheme of things isn't a whole lot.
- DOS and Windows 3.1 filenames aren't case sensitive; this means that filenames can be either upper- or lowercase.
- Filenames and directories can't include blank spaces or characters such as / \ : * ? < > . or |. All other characters available on your keyboard are legal for filenames, however.
- Neither DOS nor Windows 3.1 require you to include a file extension. However, it's a generally a good idea to do so since many applications on these systems use the file extension in order to identify what a file is.

Windows 95, 98, NT 4.0, and 2000 File Naming Rules

- Windows 95, 98, NT 4.0, and 2000 are all much more flexible than DOS or Windows 3.1 and can support filenames of up to 256 characters.
- Like their older relatives, you can't use characters such as / \ : * ? < > | or . in your filenames or folder names.
- Unlike DOS or earlier versions of Windows, spaces are okay to use.
- File extensions are also optional on these systems, but again, it's a good idea to include them because many Windows applications use this information to determine what different files are.
- Like DOS and Windows 3.1, the newer versions of Windows aren't case sensitive. For example, a filename like `arcade game graphics.bmp` is a perfectly legal filename under Windows 95, 98, NT 4.0, and 2000.

NOTE: Neither DOS nor Windows 3.1 like the longer filenames used by the newer Microsoft operating systems. They will read files created by these systems with no problem, but their filenames will be truncated after the seventh character just before the file extension. For example, the Windows 95 filename `spaceship1999.bmp` will appear as `spacesh~1.bmp` under DOS. Long filenames will display normally when using the DOS console on Windows 95, 98, NT 4.0, or 2000, however.

Macintosh File Naming Rules

- All Macintosh computers allow filenames and folder names to be up to 31 characters long.
- You can also use any character or combination of characters except for the colon (:).
- As with DOS and Windows, character case doesn't matter.
- Macintosh files don't require you to use file extensions. Unlike DOS or Windows, Macintosh applications don't rely on a file's extension to tell what it is. Rather, they use what is known as a *creator code* to identify different types of files and associate them with the applications they should work with. Every application on the Macintosh assigns files their own unique creator code. This allows you to do things such as launch the application that generated the file by simply double-clicking on its filename.

NOTE: When exchanging files and PC formatted disks with Macintosh computers running Mac OS 8.1 or lower, please be aware that Windows 95, 98, NT 4.0, and 2000 long filenames won't be preserved. These versions of the Mac OS will automatically truncate the filenames to adhere to the old, 8.3

naming standards. Mac OS 8.5 and above don't have this problem, however, and these systems will, in fact, preserve Windows long filenames.

Linux File Naming Rules

- Filenames and directories under Linux can be between 1 and 256 characters long.
- The following characters are legal for Linux filenames: a..z, A..Z, 0..9, _. The following characters have special meaning to Linux and really shouldn't be used in filenames or directories: < > ' " * { } [ ] ( ) ^ ! \ | & $? ~.
- Spaces aren't illegal in Linux filenames and directories, but they're not recommended. Use underscore (_) characters instead of spaces whenever possible.
- Do not start any file or directory name with a period (.), as this tells Linux to make it hidden from the system.
- Unlike the other platforms mentioned here, filenames are case sensitive under Linux. Therefore, Linux sees the files `stars.gif` and `Stars.gif` as two distinct files.

General File Naming Guidelines

The next step is to define the basic rules that identify the different files you create. Given that most of the graphics you design will have a specific function within a game, I suggest naming your files according to these basic guidelines:

- **Name your files logically**—This is a no-brainer. Always give your files logical, intelligent names in order to avoid any unnecessary confusion. For example, call the file that contains the spaceship sprites for level 5 of your game `spaceships.bmp` and not `ships.bmp`.

NOTE: This might cause compatibility problems with DOS systems so skip this step on this platform as necessary.

- **Consult with others**—Always check with your fellow developers and programmers when developing a file naming convention before starting a project. This will save you all time and grief later on should anyone involved have specific preferences, expectations, or needs regarding how graphic files should be named.
- **Be descriptive**—Try to be as descriptive as possible in naming your files but don't go overboard. For example, name the file that contains the alien spaceships for level 1 of your game `alien_spaceships_01.bmp`. Keep the filename restrictions of each platform in mind when naming your files. If you

intend to use multiple files of related images, you should number them sequentially, i.e., 00-99. When you run out of digits, use the letters AA through ZZ. For example, AA, AB, etc.

- **Use file extensions—**In addition to helping DOS, Windows, and Linux systems identify which program a particular file belongs to, file extensions also allow you to perform many powerful file manipulations on these systems. For example, you can decide to delete files that have a .PCX extension by typing del *.PCX or quickly copy all files to another drive that have a .BMP extension by typing copy C:\DATA *.BMP D:\BACK.
- **Adhere to the 8.3 naming scheme—**If cross-platform compatibility with DOS and Windows 3.1 systems is a concern, remember to restrict your filenames and directory names to the 8.3 naming rules described earlier in this section. Doing this will keep your filenames consistent even when used on different platforms.
- **Don't use spaces—**I suggest using underscore characters (_) in place of spaces even though the Macintosh and the current versions of Windows allow them in filenames. Doing this will give you more flexibility when performing file searches and wildcard file manipulations. It also allows you to maintain consistent filename compatibility with DOS and other operating systems including Linux.
- **Be consistent—**Once you establish a file naming scheme, stick to it. If you don't you're only asking for trouble as you'll soon experience problems finding, tracking, and maintaining your files.
- **Provide documentation—**You should always document your file naming scheme and distribute it to everyone who works with your files. The whole point of establishing your own file naming convention is wasted if you don't take the time to write out and define what your naming system actually means! Doing so will also avoid confusion regarding a given file's contents, especially when working with other people as part of a development team.

A Sample File Naming Scheme

This section provides an example of how you might opt to name your files in your own game projects.

The sample file naming scheme uses this format:

```
type-description-size.extension
```

Type:

This part of the filename indicates the type, or class, of file to which the image belongs. Please refer to Table 4-1 for a complete description of the possible image type prefixes.

TABLE 4-1: Possible Image Type Prefixes

Type Prefix	*Comments*
bkg	A background. This prefix is reserved for any image that will have one or more images displayed over it.
blk	An image block. This prefix is reserved for various image segments used for items such as status indicators and game text.
img	A generic image block. Typically, this prefix is used for title screens and other static image screens.
mnu	A menu element. Images that use this prefix can include everything from pre-made menu screens to individual button elements.
spr	A sprite image. This prefix should be used for any image that is to be animated within a game.

Description:

This is the description of the file in question.

As indicated in the earlier file naming guidelines, you should give your files logical and descriptive names. In general, try to limit your descriptions to less than 32 characters. Any more and the names become unwieldy to view and manage. Also, separate multiple word descriptions with underscore (_) characters and not spaces, such as `wilddog_running_left`.

NOTE: Limit your file descriptions accordingly in order to maintain compatibility with the Macintosh and other systems that place limits on the length of filenames.

Size:

This part of the filename contains the size of the file in pixel format such as 64x64 or 320x240.

This part of the filename is important since not all images will contain the same dimensions and there are many instances where the programmer needs exact image dimensions.

Extension:

This is the normal extension for a graphic file. Make sure you always include it so that the programmer (and other applications) will be able to instantly recognize its type.

TABLE 4-2: Example Asset Filenames

File	*Example Filename*
Game title screen	img-red_game_title-640x480.bmp
Game sprite	spr-green_dragon_moving_right-128x128.bmp
Game menu	mnu-play_button-120x40.gif
Game status indicator	blk-game_score_counter-160x20.gif

Managing and Organizing Directories

Directories (or folders, depending on your platform and nomenclature preference) allow you to store and organize groups of files much like a filing cabinet does. As such, directories can come in handy for managing the files you create in your game graphics projects.

NOTE: Directories are essentially files that contain other files. Therefore, all of the rules that apply to files will apply to directories as well.

To be effective and efficient, it's best to follow these simple rules:

- **Start fresh**—Always create a new directory for any project that is likely to produce more than one file. This will help you quickly organize and find files associated with a project. For example, you would create a directory called `JUMPER` to store the files for the new arcade game called "Jumper" on which you're going to start work.
- **Branch out**—Directories allow you to organize your files in a hierarchical, tree-like fashion. You can create special directories within directories called *subdirectories*. Take advantage of them in order to help categorize and better organize your files. For example, you might create a subdirectory called `BACKGRDS` to hold your background images and a subdirectory called `SPRITES` to hold your sprite screen.
- **Name smart**—Name your directories the same way you would name a file. That is, you should take your platform and its limitations into consideration (DOS, Windows, or the Macintosh), and use logical names, as shown in the previous example. Whenever possible, use descriptive directory names! This will help you find the files you want much faster.

Figure 4-1 shows an example of what your directories might look like in an actual project.

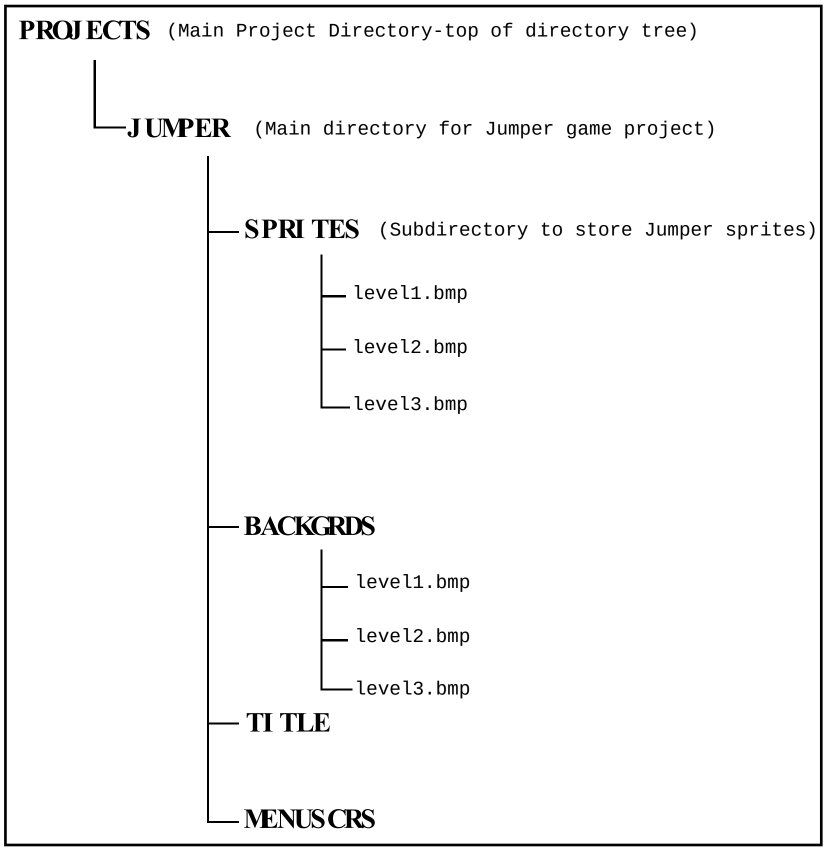

PROJECTS (Main Project Directory-top of directory tree)
JUMPER (Main directory for Jumper game project)
SPRITES (Subdirectory to store Jumper sprites)
level1.bmp
level2.bmp
level3.bmp
BACKGRDS
level1.bmp
level2.bmp
level3.bmp
TITLE
MENUSCRS

FIGURE 4-1: Example Game Project Directory

Exchanging Files Across Platforms

In a world where upwards of 90% of computers are running some version of DOS or Windows, exchanging files between different platforms is a lot easier than it used to be. However, it's still not a given, particularly with regard to non-PC systems such as the Macintosh or Linux. This being said, there are two basic levels of cross-platform compatibility that you should be worried about. These are:

- Disk compatibility
- File compatibility

Disk Compatibility

Mechanically speaking, there is really no different between how disks, be it a floppy, Zip, or CD-ROM, work across different platforms. Regardless of architecture, most computers manufactured since the late 1980s pretty much all use the same components, technology, and hardware. However, there's a huge difference between platforms in how information is recorded and stored. These differences become obvious whenever you try to exchange disks between different systems using their native formats. Without compatibility standards, such operations are usually doomed to failure.

Fortunately, there's one way to ensure almost universal disk compatibility: standardization! By this I mean that you should standardize on a single disk format for all of your disks. For obvious reasons, this standard disk format should be the DOS (FAT) format.

Macintosh Disk Compatibility with Different Platforms

- Format all floppies using the "DOS 1.4 MB" option from the Finder's Erase Disk command. This creates a 100% compatible DOS disk.
- All Macintoshes can read and write to PC formatted floppies without problems as long as the File Exchange system extension is installed and enabled. If it isn't, the Macintosh will report errors that the floppy is unreadable.
- Format all Zip disks using the *Iomega Tools* utility as it allows you to create DOS readable, removable disks. Unlike floppy disks, the Macintosh can't directly format DOS-compatible disks without using special software.
- All Macintoshes can read and write to PC formatted Zip disks without problems as long as the File Exchange system extension is installed and enabled. If it isn't, the Macintosh will report errors that the Zip disk is unreadable.
- Using CD-R mastering software such as Adaptec's *Toast*, burn a CD using the ISO 9660 format with *Joliet* extensions. *Joliet* enables you to create CDs that are readable on DOS, Linux, and Windows machines while preserving the appropriate filename length for each platform. Be sure to limit your filenames to 31 characters, however, as the Mac OS doesn't support filenames that are longer.
- All Macintoshes can read PC and Linux formatted CD-ROMs provided that Foreign File Access, ISO 9660 File Access, and High Sierra File Access are enabled.

Linux Disk Compatibility with Different Platforms

- Use the free *Mtools* suite of utilities or a similar utility. *Mtools* allows Linux users to format PC-compatible floppies as well as read, write, and manipulate DOS files.
- Most versions of Linux can mount IS0-9660 (DOS) and ISO-9660 (Windows 95/98/NT/2000) CD-ROMs.
- There are also various free utilities available that allow Linux users to read and write files to DOS formatted Zip disks as well.

DOS Disk Compatibility with Different Platforms

- DOS can format floppy disks readable by all systems as long as you stay away from extended formats. This means stick to the plain vanilla 1.4 MB disk format created by most DOS formatting utilities.
- DOS can't normally read Macintosh formatted floppy disks, removable disks, or CD-ROMs. However, using a utility such as *MacSee* by REEVEsoft, Inc. will enable DOS users to access most Macintosh formatted media.

Windows Disk Compatibility with Different Platforms

- Windows can format disks readable by all systems as long as you stay away from extended formats. This means stick to the plain vanilla 1.4 MB disk format and don't use extended disk formats, such as DMF, if you plan on exchanging your disks with other platforms.
- Windows can format DOS-compliant Zip disks using the standard *Iomega Tools* that ships with these drives.
- Using software such as Adaptec's *EasyCD Creator,* all versions of Windows other than version 3.1 can burn ISO-9660 (DOS, Linux, and Macintosh readable) and ISO-9660 Joliet format (long filename CDs readable by Linux and Macintosh systems) CDs.
- Windows machines can't normally read Macintosh formatted floppy disks, removable disks, or CD-ROMs. However, using such utilities as *TransMac* by Acute Systems will enable them to access files stored on most types of Macintosh media.

NOTE: Evaluation copies of both *MacSee* and *TransMac* are included on the book's accompanying CD-ROM. Please refer to Appendix B for more information on these programs.

File Compatibility

When it comes to transferring files between different platforms, files fall into two distinct categories: those that require some sort of conversion and those that don't. Let's tackle the ones that don't require conversion first.

File Format Conversion Issues

One of the nice things about the abundance of software in the marketplace is the fact that there have emerged some informal standards in terms of compatibility between graphics applications and the files they create. This section summarizes:

- **BMP files**—The BMP format is common enough that most non-Windows applications will support them as an input format with little or no problems. This is especially true on the Macintosh when *QuickTime* is installed. Both DOS and Linux offer more limited application support for the format but will work with it.
- **GIF files**—GIF files are accepted by virtually all major graphics applications as an input format and their content displays correctly whether you're on DOS, Windows, a Macintosh, or even a Linux box. For the time being, they are your best cross-platform file format choice.
- **JPEG files**—Like GIF files, JPEG files are accepted by virtually all major graphics applications as an input format and their content displays correctly whether you're on DOS, Windows, a Macintosh, or even a Linux box. Just recall the discussion in Chapter 3 on JPEG's limitations before using them extensively.
- **PCX files**—PCX files have been around a long time and have therefore earned a place as the de facto standard on many platforms. DOS applications have the most extensive PCX support and there are an ample number of programs on the Windows platform that are compatible with this format as well. The same does not hold true for the Macintosh and Linux platforms, however.
- **PNG files**—PNG is still a relatively new file format. However, it will soon have the same level of support across all platforms that GIF currently enjoys. Until then, try to be somewhat circumspect regarding its use until all graphics applications and programming tools are updated to be compatible with it.
- **PSD files**—*Photoshop* files generated by one platform can be read by another (i.e., Windows to Macintosh and vice versa) as long as the target machine has a version of *Photoshop* that's compatible with the original file.
- **TIFF files**—TIFF files are very similar between systems like the Macintosh and Windows. However, they're not completely identical. There's a subtle difference in how they're saved that prevents them from being read directly on either platform without taking special precautions. So, if you plan to use TIFF files on other platforms, make sure you save them with the correct byte order.

This is because there's a specific byte order for both Windows and the Macintosh and neither platform is compatible with the other.

Aside from these exceptions, using all other graphic file formats across platforms is a crapshoot. Most of the other formats mentioned in Chapter 3 are either proprietary to a specific piece of software or only have limited support from graphics applications on different platforms.

File Naming Across Platforms

As discussed earlier in this chapter, each platform has different file naming standards. Table 4-3 highlights how you would handle this issue while moving files across different platforms:

TABLE 4-3: An Overview of How to Handle Filenames Across Platforms

Source Platform	*Destination Platform*	*Comments*
Linux	DOS/Windows 3.1	N/A
Linux	Windows 95/98/NT/2000	N/A
Linux	Macintosh	N/A
Macintosh	DOS/Windows 3.1	If you know you'll be moving files over to DOS ahead of time, cover your bases by limiting your filenames to the DOS 8.3 convention. Otherwise, DOS will mangle your filenames. If you're using Macintosh formatted media, a utility such as *MacSee* will allow DOS/Windows 3.1 users to read the Macintosh files and convert them into the proper filename length.
Macintosh	Windows 95/98/NT/2000	These versions of Windows can handle the Macintosh file length but will need a program such as *TransMac* to read Macintosh formatted media. If the source media is PC compatible, then there's no conversion necessary.
Macintosh	Linux	N/A
DOS/Windows 3.1	Windows 95/98/NT/2000	Don't do a thing. These versions of Windows are fully backward compatible with DOS and Windows 3.1.
DOS/Windows 3.1	Macintosh	Don't do a thing. The Macintosh with File Exchange enabled is fully compatible.
DOS/Windows 3.1	Linux	Don't do a thing. With a utility such as *Mtools*, Linux is fully compatible.

Source Platform	*Destination Platform*	*Comments*
Windows 95/98/NT/2000	DOS/Windows 3.1	If you know you'll be moving files over to DOS ahead of time, cover your bases by limiting your filenames to the DOS 8.3 convention. Otherwise, DOS will mangle your filenames.
Windows 95/98/NT/2000	Macintosh	Limit your filenames to 31 characters. Other than that, the Macintosh with File Exchange enabled is fully compatible.
Windows 95/98/NT/2000	Linux	With the proper tools installed on the Linux end, Linux is fully compatible.

Compressed Files

One last issue to consider is that of compressed files. Compressed files are extremely useful for efficiently exchanging files between platforms. Unfortunately, there exist a number of different compression formats, and each platform has its own means of dealing with them.

Table 4-4 provides information on these file compression formats.

TABLE 4-4: Common File Compression Formats

Platform	*File Format(s)*	*File Extension*	*Comments*
Linux	gzip	.gz	Gzip is the standard file compression format used on UNIX type systems. Almost all Zip-compatible compression programs can read and write gzip files.
Macintosh	Stuffit	.sit	Stuffit is the standard Macintosh file compression format. Support for it is scarce on the Windows and DOS platforms. However, Aladdin System's *Stuffit Expander* can read them.
DOS/Windows 3.1	Zip, ARJ, RAR, or LZH	.zip, .arj, .rar, .lzh, .lha	Of the formats listed here, Zip is the most common. The Zip format is a de facto standard and any properly created Zip file should be readable on any platform with the appropriate reader. The ARJ and RAR formats are common and tend to be popular in Europe.

Platform	*File Format(s)*	*File Extension*	*Comments*
Windows 95/98/NT/ 2000	Zip, ARJ, RAR, or LZH	.zip, .arj, .rar, .lzh, .lha	Of the formats listed here, Zip is the most common. The Zip format is a de facto standard and any properly created Zip file should be readable on any platform with the appropriate reader. The ARJ and RAR formats are common and tend to be popular in Europe.

NOTE: Included on the book's accompanying CD-ROM are versions of utilities for both DOS and Windows, which can read and write all of the file compression formats described here.

File Backups

Why back up your files? Well, the answer is simple: computer files exist as bits of electromagnetic data. As such, they are vulnerable to a whole slew of circumstances that can render them totally useless in a blink of an eye. Such events include:

- Accidental file deletions (quite common)
- Hard drive crashes (very common)
- System crashes (extremely common)
- Fire, earthquake, flood, or some other act of God (rare, but hey, they do happen)

Imagine how you would feel if you had worked 100 hours on a particular set of game graphics only to lose everything due to a hard drive crash. I don't think you would be overjoyed about the situation, do you? Because of this, you're only asking for a world of pain if you don't take the precaution and time to back up your files on a regular basis.

Fortunately, implementing a basic file backup strategy or plan isn't very difficult or time-consuming and there are quite a few options available to you. But, before you start backing up your files, ask yourself some important questions about your specific needs, including:

- How valuable are your files? Do they really need to be backed up after all?
- What would be the consequences of losing your files? Will you lose time and/or money as a result? Or would it not be a big deal?
- Could you easily replace them? If so, how long would it take you to do so?
- Do your files change often? If so, how often? Do you need to keep older versions of your files?

- Are your files very large?
- Do your files need to be secured? Do you need to protect them from unauthorized access or duplication?
- Do you need to transport or distribute your backed-up files to alternate locations?
- Once backed up, how important is the immediate access to them?

Your answers will dictate the solution that's right for you. In a nutshell, you can group these file backup solutions into seven categories:

- Importance
- Change
- Device capacity and performance
- Cost
- Portability
- Reliability
- Security

Backup strategies are based on a combination of these categories, and you should develop a backup strategy that regularly takes these issues into consideration.

Importance

Your files are important to you, aren't they? After all, during the average game project, you'll probably wind up spending hours, days, or even weeks creating and tweaking them to get them looking just right. This being said, you probably wouldn't want anything to happen to them, right? Therefore, any backup strategy you adopt should take into account the potential cost to you in terms of the time and money that you'd need to invest should you need to replace lost files. This in itself should encourage you to back up your files at least every day.

Change

How often your files change figures quite prominently in any backup strategy. Files that change frequently are more prone to corruption and loss than files that do not. To make matters more complicated, these files always seem to be your most important ones! Your strategy should include a plan on how to handle them, such as backing up files that change frequently to ensure that a recent copy of all files exists at all times.

Device Capacity and Performance

Different backup technologies offer different levels of storage capacity and performance. Some systems are capable of copying and storing many files very quickly while others are only capable of copying a few files relatively slowly. Furthermore, some backup devices might not be available for your particular system. Therefore, your backup strategy must consider your particular hardware setup and operating system, as well as personal needs. For example, you may find that certain backup technologies aren't available for your computer. In addition, you may discover that your particular need for backup files is very limited and you don't have to resort to using a sophisticated backup solution.

Cost

Your backup strategy must weigh your financial situation with that of the importance of your files. Faster, higher capacity, and more full-featured backup devices tend to be much more expensive than slower, more limited backup devices. Also, your time is valuable and making backups takes time. You need to evaluate whether your files are worth the cost of what you could be doing with your time in lieu of making backups.

Portability

The portability of different file backup media and devices can also influence the strategy you choose to implement. For instance, in situations where files must be circulated within your office or sent to another location, you will probably want to use a backup device to physically transport your media. You should also choose a backup device that uses media which is compatible with other devices commonly found and used in the environments you regularly access.

Reliability

Different backup devices also offer different levels of reliability. Some backup media is more prone to sporadic corruption than other media. You should take this into account before committing to a solution in order to avoid any nasty surprises. After all, you don't want to go through all of the trouble of backing up your files only to find them ruined by backup media that has gone bad, do you?

Security

You should consider the security of your files to be of paramount importance in implementing any backup strategy. The whole point of backing up your files in the first place is to keep them safe. This means that your backups should be protected against traumatic events such as theft, fire, and the like. Along the same lines, your backups should also be secure from prying eyes and unauthorized use and access. The last thing you want is for someone to steal your intellectual property. Implementing proper security in your file backups can go a long way in preventing this from happening.

Backup Media

This section will describe some of the more common file backup technologies in common use.

- Floppy disk drives
- Zip drives
- CD-R/CD-RW drive
- Internet-based backup systems

Floppy Disk Drives

Contrary to popular opinion, there's still plenty of life left in the venerable floppy disk and they offer a number of advantages when it comes to backing up small files, including:

- **They're sturdy—**Despite their name, floppy disks are fairly rigid and able to stand significant abuse before failing. This keeps your files reasonably safe.
- **They're cheap—**Floppy disks only cost pennies when purchased in bulk, making them the most inexpensive of all of your backup options.
- **They're portable—**The 3.5" floppy disk is small enough to fit in one's shirt pocket. This makes it easy to transport files using the "sneaker net" across the office or across one's home.
- **They're compatible—**PC formatted floppy disks are readable and compatible with DOS, Windows, and Macintosh platforms. However, the same is not true the other way around. Macintosh formatted floppies are not compatible with DOS or Windows systems without using special software.
- **They're ubiquitous—**With the exception of newer Macintosh models such as the iMac and G3/G4 series, 3.5" floppy disks are installed in and compatible with virtually every PC manufactured since the early 1990s. In fact, there are probably hundreds of millions of installed floppy drives, which virtually assure its ubiquity. This alone makes them a good, inexpensive choice for occasional backup duty.

These points being made, floppy disks have their share of faults, including:

- **They have limited storage capacity—**With average capacities in the neighborhood of 1.4 MB, they only have enough space to handle one or two

640x480, 24-bit images or about eight to ten, RLE compressed 640x480, 8-bit images. This fact keeps them relegated to all but the smallest backup jobs.

- **They're slow**—Floppy drives are notoriously slow, usually offering only about 64 KB/sec of sustained transfer rate in even the best of conditions. Frequently, the host system's OS slows floppy access even more. This makes them unsuitable for fast, frequent file backups.
- **They offer poor security**—Floppy disks are prone to theft and the files contained on them are easily copied. This makes them a poor choice if data security is important to you.

NOTE: I have decided not to mention the so-called LS-120 "Super Disk" technology in this discussion because it is not a widely popular storage format at this time.

Zip Drives

Iomega's Zip disk drive is known as the "super floppy" for good reason. This versatile storage medium offers many advantages, including:

- **Large installed base**—Since its introduction in 1994, the Zip drive is second only to the floppy disk in terms of installed numbers. There are tens of millions of Zip-compatible drives and several times that number of Zip disks in use around the world. These numbers ensure that you're not going to back up your files to a dead medium.
- **Respectable storage capacity**—Unlike floppy disks, Zip disks can store approximately 100 MB of data, which is equivalent to over 70 floppy disks! What's more, newer Zip models support disks that can store as much as 250 MB of data. Even at the 100 MB capacity, the average Zip disk can store a dozen or more full-color 24-bit files or hundreds of RLE compressed, 8-bit graphics files. This is enough for most purposes.
- **Cross-platform compatibility**—Zip drives and media can be used on Windows, Macintosh, and Linux machines. Macintosh systems can read both natively formatted Zip disks and PC formatted Zip disks. However, like floppy disks, Windows machines can't read Macintosh formatted Zip disks without using special software such as *TransMac*. Despite this, Zip disks are very cross-platform friendly.

As with their floppy cousins, Zip drives aren't perfect either. Their problems include such things as:

- **Reliability problems**—Although I've personally never experienced problems with them, there are plenty of users who have. There are some known quality control issues with certain Zip drives that can cause one to either damage or lose their data in certain situations. Therefore, if the integrity of your data is very important to you, you might want to look elsewhere for a more robust backup solution.

- **Performance issues**—Zip drives come in many flavors, including SCSI, USB, and parallel compatible models. Zip drives operate similar to floppy drives and aren't speed demons to begin with. How you interface the Zip drive to your system will have a significant influence on how fast a Zip drive will copy your files. In general, SCSI-based Zip drives are the fastest, followed closely by USB drives, and, finally, parallel drives. If backup speed is an issue with you and you have a slow Zip drive, it may not be the backup solution for you.
- **Expensive media**—Zip media is significantly more expensive than floppy disk media or even CD-R media. Prices have not gone down substantially over the years, making the cost per megabyte on the high side of available backup storage options. This is certainly something to consider, especially if you're price conscious.
- **Poor security**—As with floppy disks, Zip disks are prone to theft and the files contained on them are also easily copied. This makes them a poor choice if data security is important to you.

CD-R/CD-RW Drives

CD-R/CD-RW drives are recordable versions of the compact disc. At one time, CD-R (compact disc-recordable) and CD-RW (compact disc-rewritable) drives were out of reach for the average person. However, with the massive price drops of recent years, this is no longer the case. Compared to floppy or Zip disks, CD technology offers some incredible advantages such as:

- **Massive storage capacity**—Even in today's world of multi-gigabyte hard drives, the CD's 650 megabyte capacity is still nothing to scoff at. You can potentially store hundreds of full-color, 24-bit, 640x480 images on a CD or thousands of RLE compressed, 8-bit color, 640x480 screens. There's plenty of room for either and then some.
- **Reliability**—Compact discs store data digitally and not magnetically. Therefore, unlike magnetic media such as floppy disks or Zip disks, CDs aren't prone to the same hazards. This means files stored on CDs will usually last much longer than files stored on magnetic media. In fact, this data can often last for years, rather than weeks or months, without any noticeable problems or degradation.
- **Inexpensive media**—CD-R media ranks just next to floppy disks in terms of price. Simply put, CD-R media is very inexpensive. This makes it a good choice for making numerous backups of important files. The same does not hold true for CD-RW media, however, as it's still on the high side.
- **High degree of portability**—CD-R media (not CD-RW) can be read in practically any CD-ROM drive currently in use as long as they are formatted in the

ISO-9660 standard. As virtually all systems manufactured since the early 1990s come with CD-ROM drives, this makes CD-R media almost as ubiquitous as the floppy disk.

Of course, CD-R and CD-RW drives do have their share of disadvantages, including:

- **Write once medium**—CD-R drives can only write contents onto a CD one time. After that time, the disc may no longer be recorded on. While CD-RW drives do offer the ability to write to discs multiple times, they generally can't write to discs at a file by file level. This makes them useless for backing up frequently changed files.
- **Slow performance**—Most CD-ROM drives operate at a maximum of only 300-600 KB/sec. While much faster than either floppy disk or Zip drives, this speed still pales in comparison to the average hard drive. What's worse, since most CD-R and CD-RW drives don't yet operate at the packet level, you must write the contents of the whole CD at once. And, if you're backing up several hundred megabytes of files, this can turn into a quite lengthy process.
- **Limited compatibility**—CD-R and CD-RW media is incompatible with many older CD-ROM drives. What's more, CD-RW discs aren't as cross-platform friendly as, say, the average floppy or Zip disk is. If a CD-R isn't written using the cross-platform ISO-9660 format, one could encounter compatibility problems between DOS, Windows, and Macintosh systems. Again, most Macintosh systems can usually read the contents of PC formatted CDs but the same is not true the other way around.
- **Poor security**—CD-R and CR-RW media is difficult to copy-protect. This means that their contents are easily open to unauthorized access. This makes them a poor choice if data security is important to you.

NOTE: Contrary to popular belief, CD-R/CD-RW media does not last forever. The longevity of recordable CDs depends strictly on the quality of the media used. Therefore, I strongly recommend perusing the official CD-R FAQ pages at `http://www.fadden.com/cdrfaq/` for more information.

Internet-Based Backup Systems

The concept of an Internet-based file backup system is a relatively new and exciting one. It offers users such advantages as:

- **Strong security**—Unlike any of the other backup devices mentioned so far, files that are backed up via the Internet are less prone to physical damage, i.e., theft, fire, etc., because they are actually stored at one or more remote facilities. This makes Internet file backups an interesting and potentially more secure alternative then some of the other devices discussed here.

- **Encryption**—Most Internet-based file backup systems can take advantage of existing and established Internet-based security and encryption protocols. This gives your files an extra measure of security by keeping them safe from unauthorized access or use. On the other hand, most floppy, Zip, and CD-R/CD-RW devices can't provide this without special software or tricks.
- **Convenience**—Anyone with an Internet connection and a Web browser can use an Internet backup system. Furthermore, you can access such backup systems from school, work, or even the comfort of your home. If you need to back up files frequently, this could be a viable solution for you.
- **Universal compatibility**—Because they run off the Internet, such backup schemes don't require expensive hardware or complex software. You can use such systems independent of the platform that originally created the files.

Like the other backup technologies mentioned here, Internet-based backup systems have a number of disadvantages, including:

- **Slow file transfer speed**—Unless you have a very fast Internet connection such as a T-1, DSL, or cable modem, Internet-based file backups can be tedious and slow. Because of this, you might not want to use this as your primary backup system, especially if speed is important to you.
- **Limited storage capacity**—Internet backup schemes tend to be limited in storage capacity. Although different services vary, most seem to limit you to between 10 and 100 megabytes of file storage. In comparison, CDs and Zip disks offer this and more.
- **Cost**—Some Internet file backup systems are free; however, most of them cost between $30 and $50 per month. So, unless you have specific needs, you may find other backup technologies cheaper in the longer run, especially if you're on a budget.

NOTE: I have had good experiences with both FreeDrive (`htttp://www.freedrive.com`) and iBackup (`http://www.ibackup.org`). Accounts for these Internet backup services are either free or low-cost and you can store between 50 and 200 megabytes of information per account. That's quite a deal considering the extra security and peace of mind these services provide.

NOTE: I decided not to mention tape backup devices in this discussion because tape is largely a sequential backup medium. In other words, with tape you will usually be forced to back up everything at once rather than just a few files. Tape drives are also not very common in most homes and small office environments, which makes them less attractive, especially if exchanging files with other people is important to you.

File Backup Strategies

Everyone will have their own tastes and preferences when it comes to backing up their files. And, that's fine. I don't want to suggest something that will cramp anyone's style. However, if you consider your files important, you will adapt some sort of backup system right away.

To minimize data loss and computer downtime when a hard disk crash or computer failure occurs, you should follow these rules when backing up your data:

- **Daily Basis**

Without fail, back up your important files on a daily basis. As files change constantly, the loss of even one day's worth of files can be devastating.

Perform a backup of all of the files and directories that have changed since you last worked on them. This can be done manually, but please be aware that modern operating systems and graphics applications tend to modify many files simultaneously. Therefore, you can't always be assured that you'll have accurate file backups if you perform the backup procedure manually. Instead, consider investing in software that performs what is known as an *incremental backup*. Incremental backups select all the files that have changed since the previous backups by consulting the archive date in a file's directory entry. When the backup is completed, the archive information is then updated to indicate which files have been backed up. Doing this allows files to be ignored the next time a backup is performed unless they have been modified or changed, thus saving you time.

I also suggest backing up your files immediately before turning off your computer for the day/night. Just be aware that this can take a while.

NOTE: Some backup programs can automatically back up your files based on a predetermined schedule. Be sure to look into it as this can be a real time saver.

- **Monthly Basis**

As your time allows, try to back up your entire system at least once a month. This should be in addition to your daily file backup regimen.

Perform a full backup of your hard disk. Again, this can be done manually, but isn't recommended. You're better off using specialized backup software that will ensure that all files are properly copied. The backup software will also ensure that future backups go faster and more efficiently since it will be able to track the history of changes to your files and drives. Once you have successfully backed up the contents of your hard drive, place these backups in a safe place.

Weekends or lunchtime are particularly good times to perform this fun task, as a full system backup can take anywhere from 30 minutes to several hours depending on the size of your hard drive and number of files involved.

NOTE: You are encouraged to make frequent backups of your backups! Like anything else, even backups can go bad. Plan for this and you'll thank me later, especially after you experience your first system crash and attempt to restore your files with a corrupted backup copy. To keep your backups safe, always store them in a cool, dry, and static free environment. This is especially true for magnetic media, as the information on them tends to expand when exposed to hot temperatures. Static electricity can also blank most magnetic media in seconds, so keep your backups away from anything that can accidentally generate a static charge as well.

A Final Word about File Backups

Try to maintain at least two sets of backups made using the incremental backup procedure and rotate these sets in order to be prepared for a system crash or a similar computer disaster. Doing this ensures that your file backups are always stable and fresh in case the worst should happen.

For purposes of illustration, here's a rundown of my own backup strategy:

- I save all of my files every 10-15 minutes. This minimizes the possibility of losing any changes if my machine crashes or the power suddenly cuts out.
- At the end of every work session, meaning at least once a day, I back up my current work files to a fresh Zip disk.
- Before I go to bed, I always make a Zip-compressed archive of my current work files and upload them to one of my `http://www.ibackup.org` or `http://www.freedrive.com` Internet storage accounts. Doing this gives me an extra level of security as it provides me with a second set of backups that is off premises in case my Zip disk becomes corrupted or damaged. Furthermore, I can use this system as a means of archiving and tracking older versions of my files in case I ruin my originals.
- Every two weeks I make backups of my Zip disk to ensure that I always have a good backup copy to restore from.
- Once I complete a major project, I burn a CD-R using high quality media. This gives me a reliable and largely indestructible master set of files.

NOTE: To get your backup strategy off to a good start, I've made arrangements to include the full-featured shareware version of *Fileback PC*, a powerful, low-cost backup utility, on the book's accompanying CD-ROM. Refer to Appendix B for additional details on this program.

Version Control

Version control is a system by which you can record and track the history of your files. This allows you to go back to an older version of your file at any time, and to monitor what was changed, when it was changed, and by whom.

Traditionally, version control has been most at home with programmers who need to keep track of constantly changing source files. However, everyone involved with managing ever-changing files can benefit, especially those who design computer game artwork.

How Version Control Can Help

You can use a version control system to:

- Go back in time
- Compare revisions
- Preserve content safely
- Lock files

Go Back in Time

With a version control system, you can go back in time and retrieve virtually any version of your graphic files at any time. Under version control, every change to a file is saved and marked as a revision. Every revision has unique identifying information saved with it, allowing you to restore files that have changed two, three, ten, or even a hundred times. This allows you to restore "good" versions of your files in case you recently made changes with them and weren't too pleased with the results.

Compare Revisions

Using a version control system, you can easily see what was changed between any two versions of a given file. This is very useful for studying how your files have changed over time, for better or for worse.

Preserve Content Safely

A version control system allows you to preserve the content of any file you create. Your work is never lost no matter how badly you mangled an image because a pristine, or "safe," version of it is always available. This alone makes such a system useful given the frequency that changes and, ultimately, mistakes are made to game artwork.

Lock Files

In a multi-user environment, a version control system can also lock files and prevent two users from modifying (and ruining) the same file. You can also keep tabs on who makes changes to your files and when. This lets you take control of your files and prevents them from being damaged accidentally by other people.

Granted, using a version control system isn't for everyone and they do have their disadvantages, including:

- **Complexity**—Most version control systems tend to be very difficult to learn due to their overall complexity and wealth of esoteric features and options. This in itself can turn potential users off to such a system. To make matters worse, very few version control systems run under Windows, making them even more difficult to operate and configure.
- **They're cumbersome to use**—Similarly, version control systems can be difficult to use. Some people won't like them because they place too many restrictions on their workflow, while others won't like them because they slow down or interfere with the creative process.
- **They're pricey**—Some version control systems can be expensive to buy and implement. That generally makes them unattractive to folks on a tight budget.

Implementing Version Control

Implementing version control can be as simple as installing a version control system on your computer and checking your files into it. However, it's also possible to use a "poor man's" implementation as well, especially if you don't want to go to the trouble of working with such a system. To do this, simply append a version number at the end of your files. For example, to distinguish between version 1 and version 2 of the file `sky.bmp`, you'd name the file `sky.bmp.1` and `sky.bmp.2`, etc. This technique will work fine for Macintosh systems and all versions of Windows except 3.1. It also won't work for DOS as it can cause some applications to choke since they're expecting a standard, three-character file extension, not to mention an eight-character filename. Still, this system will work as long as you adhere to it.

A Final Word about Version Control Systems

For small projects involving few files, I probably wouldn't recommend employing a version control system. It's just too much trouble and fuss. However, as your projects get larger, more complex, and start to involve more people, you may want to use one. Version control systems work best in these scenarios, as their revision tracking and file locking features really go a long way in avoiding catastrophe.

NOTE: To help introduce you to version control, I've included a copy of *CS-RCS*, a full-featured Windows based version control system on the book's accompanying CD-ROM. Check Appendix B for more information.

Basic Asset Management

What exactly is *asset management*? In a nutshell, asset management at its simplest level is a process by which one can organize their graphic images. As you begin taking on larger and larger game projects, it will quickly become evident that your graphic files will soon become hard to manage. Even the most well organized person may eventually encounter difficulty finding specific images as the images accumulate. Just as one would employ a filing system for their important documents, one also needs a filing system for their collection of graphic files. This is where a dedicated asset management system comes in. With one, you'll be able to find even your most obscure files quickly and easily.

The advantages of using a dedicated asset management system versus simply lumping all of your files together are many. First, with a dedicated asset management system, you can generate a database of all of your images. This makes your files easier to manage and track as you add or remove files from your overall image collection. Second, an asset management system will allow you to associate comments and notes with each image. This allows you to provide details on each file in your collection. For example, you could make a note to yourself about a specific file's use in a game or special issues about its palette. Third, a dedicated asset management system will allow you to generate thumbnails of all of your images so you can easily visually browse through your image collection to make sure that you find the file you're interested in. In addition, asset management systems can record other crucial information about your files such as their creation date, modification date, and physical dimensions. You can't even come close to doing any of these things using directory naming schemes and frankly, I wouldn't even try.

Do You Really Need an Asset Management System?

Okay, an asset management system sounds great but do you really need one? Well, that really depends on your particular situation. If you're confident that your game projects will seldom grow beyond a handful of files, say, a dozen or so, then no, you probably don't. For that small amount of files an asset management system would just be overkill and probably doesn't make sense. However, if you start seeing a trend where your game projects routinely generate dozens or even hundreds of graphic files, an asset management system may be just what the doctor ordered.

Choosing an Asset Management System

As one can expect, asset management systems come in all shapes and sizes as well as price ranges. The most sophisticated implementations utilize network based client-server architecture and can easily handle several hundreds of thousands of assets. As our needs tend to be a bit more modest that that, we can get away with a much more rudimentary system.

For our purposes, I've identified several features that an asset management system should have:

- Database driven
- Thumbnail support
- Asset keywords
- Large catalog capacity
- Multiple image catalogs
- Low cost

Database Driven

The asset management system should support a method of adding all of your files into a database. This makes tracking and managing your graphic files a breeze, especially once your image collection starts to contract and expand. Don't use any asset management system that doesn't offer this feature because it's so useful to your asset management strategy.

Thumbnail Support

The asset manager should allow you to browse the contents of your image collection via thumbnails, or smaller versions of your original images. Thumbnails can make it easy to quickly pick out specific images from your collection as opposed to manually hunting for files. Don't use any asset management system that doesn't offer this feature because it can be such a time saver.

Asset Keywords

The asset manager should allow you to add notes, comments, keywords, or any other written data to your image collection. This feature enables you to quickly search for images that meet one or more criteria. For example, you could use it to quickly locate all images in your collection that contain the phrase "spaceships" and that are 320x200 pixels in size. Although this isn't required to make your asset management system useful, it's definitely a nice feature to have and is guaranteed to save you countless time on larger game projects.

Large Catalog Capacity

The asset manager should be able to handle image catalogs of at least 1,000 distinct files. This should give you more than enough room to manage assets for even the largest of game projects. This isn't a requirement, but again, it's another feature that's nice to have. After all, if your asset manager runs out of room in its database, the whole point of using an asset management system in the first place becomes moot, right?

Multiple Image Catalogs

Any asset management system you employ should be able to work with separate image databases for each of your game projects. As you take on more projects, you'll find this feature handy as you try to leverage images you created for older projects for use with your new ones, etc. Such a feature also makes managing your assets that much easier.

Low Cost

This goes without saying! Although asset management is important, it shouldn't be too expensive. Many of us are on budgets and don't need the "firepower" offered by many of the high-end asset management solutions. Look for something that meets or comes close to meeting most of the features here for the lowest price and you'll be in good shape.

One product that comes to mind is *Extensis Portfolio*. I like *Portfolio* because in addition to providing all of the features mentioned here and more, it's cross-platform (runs on Windows 95, 98, and NT 4.0, and the Macintosh). It also costs less than $100.

NOTE: For your convenience, there is a 30-day trial version of this program on the book's accompanying CD-ROM. Please refer to Appendix B for more information.

Chapter 5

Evaluating Graphics Creation Tools

In this chapter, you'll learn about:

- **Graphics creation tool categories**
- **Evaluating painting programs**
- **Evaluating capture utilities**
- **Evaluating viewers/converters**
- **Evaluating palette tools**

Graphics programs can provide the arcade game graphics artist with a variety of powerful, creative tools. It's no secret that having access to the right tools can save you time, make you more productive, and improve the overall quality of your artwork.

In order to find the right tool, you first need to know what features are the most important. And that's exactly what you can expect to learn in this chapter.

Graphics Creation Tool Categories

There are really four types of graphics programs that are useful for designing artwork and animation for arcade-style games. These categories include:

- Painting programs
- Screen capture utilities
- Image viewers/converters
- Palette tools

Painting Programs

Painting programs are akin to word processors for graphic images. They are programs that enable you to create graphics from scratch or manipulate pre-existing images. All painting programs provide a basic set of tools to draw shapes such as lines, rectangles, and ellipses. In addition to these tools, they also provide the ability to add text, change color definitions, and perform various other enhancements to images.

Painting programs are the primary tools for the arcade game graphics artist. The more sophisticated painting programs are known as *image editors*. The difference between image editors and painting programs isn't always that clear cut, but in general, image editors are more specialized at working with high-resolution images, such as scanned photographs, whereas painting programs are more specialized at creating original artwork.

There are essentially two types of painting programs available: *palette based* (8-bit) and *true color* (24-bit).

Although both types of programs are largely similar to each other in terms of operation and general feature sets, there are some important differences worth mentioning:

- **Color support**—True color painting programs typically offer much better color support than palette-based programs. Palette-based painting programs are limited to working with images that contain a maximum of 256 colors, while true color painting programs can work with images that can contain up to 16.7 million colors.

- **Special effects**—True color painting programs tend to offer a greater variety of special effects and image processing functions than most palette-based painting programs offer. Furthermore, certain special effects can only be applied in high color display modes that most palette-based painting programs can't normally support.
- **Layers**—Because they can work in high color depth display modes, true color painting programs often support what are known as *layers*, or virtual acetate sheets that allow you to create certain visual effects. Among other things, layers allow you to stack images on top of each other and arrange them in various ways. Unfortunately, palette-based painting programs do not support layers.

In terms of game artwork, each type of program also has its place. Generally speaking, you'll find these observations to be true:

TABLE 5-1: Game Artwork Recommendations for Painting Program Types

Game Artwork Type	*Palette-Based Painting Program*	*True Color Painting Program*
Title Screens	Recommended.	Highly recommended.
	Better for screens that use up to 256 or fewer colors or that contain large areas of flat color.	Better for screens that use more than 256 colors, contain photo-realistic artwork, or use subtle shading and blending effects.
Menu Screens	Recommended.	Recommended.
	Better for screens that use up to 256 or fewer colors or that contain large areas of flat color.	Better for screens that use more than 256 colors, contain photo-realistic artwork, subtle shading and blending effects, or incorporate transparent/translucent effects.
Background Screens	Recommended.	Highly recommended.
	Better for screens that use up to 256 or fewer colors and that don't require much color fidelity.	Better for screens that require lots of color fidelity, contain photo-realistic artwork, or use subtle shading and blending effects.
Background Objects	Highly recommended.	Not recommended.
	Well suited for this type of artwork.	Not particularly well suited for this type of artwork.
Sprites	Highly recommended.	Not recommended.
	Well suited for this type of artwork.	Not particularly well suited for this type of artwork.

Examples of painting programs include *GrafX2* (palette based) and *Paint Shop Pro* (true color).

NOTE: There also exists a subclass of palette-based painting programs called *sprite editors*. Sprite editors are specially optimized for creating and animating game sprites. However, because traditional painting programs offer most of the same functionality, they have largely fallen out of favor with game developers. The few times you do see them still being used are as part of programming or multimedia-authoring environments.

Screen Capture Utilities

Screen capture utilities are programs that allow you to take "snapshots" of whatever is currently displayed on the screen. You can use such programs to capture the contents of the entire screen, specific windows, or just certain portions. Some of them will even let you capture sequences of events such as moving your mouse across the screen.

Screen capture utilities can really come in handy when you need to "borrow" certain elements from your favorite arcade game in order to see how something was drawn.

Examples of screen capture utilities include such programs as *HyperSnapDX* and *SnagIt*.

Image Viewers/Converters

Image viewers/converters are a class of programs that allow you to view and convert graphic images from one file format to another. With them, you can convert even the most obscure graphic file formats into something your painting program can use. This is especially important since most painting programs aren't capable of reading or writing every file format you're likely to encounter.

In addition to converting between different file formats, most image viewers/converters also allow you to apply special effects to images including resolution changes and color depth reductions.

Examples of image viewers/converters include such programs as *SEA* and *XNView*.

Palette Tools

Palette tools are special programs that allow you to construct and modify custom color palettes for use with your game artwork. Among other things, these programs can be used to build cross-platform color palettes and extract color palette definitions from existing images.

And, although palette tools aren't really needed if your painting program has all of the necessary color tools, they are useful for certain situations and are worth keeping around.

Examples of palette utilities are programs like *Opal* and *PalMerge*.

Evaluating Graphics Tools and Essential Features

Graphics programs are only as good as the tools they offer. As such, this section examines the most important tools needed for game graphics creation.

For your convenience, I have taken the liberty of organizing these according to their function, and where applicable I have made specific recommendations on what features a given tool should support.

Essential Painting Program Features

Painting programs offer designers a wealth of interesting and powerful tools with which to create their artwork. However, it is important to point out that only a few of them are actually useful to game graphics designers. Designing arcade game artwork is a very specialized skill and so are the tools we require.

This being said, it is the purpose of this section to identify and discuss which tools you should be concerned with when considering whether or not to use a particular painting program.

The tools to be discussed fall into several categories and include:

- Brush tools
- Shape tools
- Block tools
- Navigation tools
- Color tools
- Image processing tools
- Special effects tools
- Other tools

NOTE: This section comprises the largest part of the chapter for the simple reason that painting programs are your primary graphics creation tools.

Brush Tools

This group of tools is responsible for drawing/painting pixels with variable degrees of precision. They include:

- The Pencil tool
- The Brush tool
- The Airbrush tool

The Pencil Tool

The Pencil tool lets you paint pixels in freehand fashion. This tool usually draws dots or lines in a single color using a fixed width and style. It is the default drawing tool in most programs.

The Pencil tool is used to drawing all sorts of freehand shapes. It's also great for situations that require precise control over pixels, such as doing close-in, pixel-by-pixel editing with the Zoom tool.

Feature Watch:

- Look for a program that allows you to set the spacing between pixels as they're painted. Such a feature can provide you with a higher degree of control over the shapes you draw with this tool.

Example:

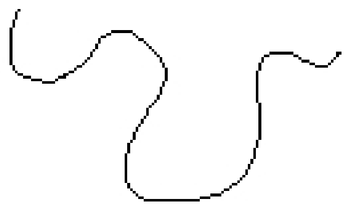


FIGURE 5-1:
Pencil Tool Example

The Brush Tool (a.k.a. Paintbrush)

The Brush tool lets you paint pixels in soft strokes of color. It works just like a traditional painter's brush except that this one paints with pixels, not with pigment. Most programs allow you to choose from several different brush shapes and styles. Some programs even let you define your own brushes by allowing you to paint with screen blocks captured by the Selection tool.

The Brush tool is used to paint large areas of the screen with swaths of color. Unlike the Pencil tool, it's ideal for any situation that doesn't require a high degree of precision or when you just want to cover wide areas of the screen with color quickly.

Feature Watch:

- Look for a program that lets you choose from several different brush shapes. This gives you more control over the pixels you paint.
- Look for a program that lets you define any screen block and use it as a brush. This effectively allows you to define your own brush shapes to suit any purpose.
- Look for a program that allows brush shapes to be anti-aliased. This feature will allow you to draw shapes using smoother brush strokes than is normally possible.

Examples:

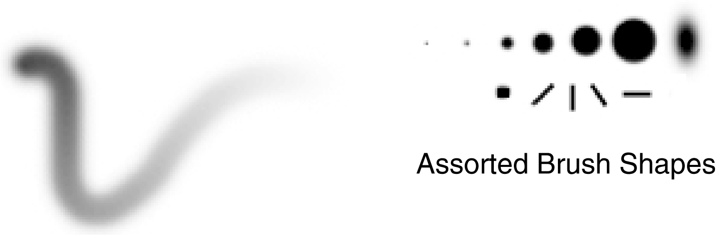


FIGURE 5-2: Brush Tool and Brush Shapes Example

NOTE: If you're looking for a true color painting program, make sure it supports variable brush stroke pressure for this tool. This allows you to paint objects in a manner similar to a natural media painting, like watercolors, and can be used to create many interesting effects.

The Airbrush Tool (a.k.a. Spray Can)

The Airbrush tool allows you to paint pixels on the screen as if you were using a can of spray paint. Because of this, some programs refer to this tool as "the spray can." With this tool, spraying in one spot of the screen will eventually fill that area with solid color.

The Airbrush tool is useful for shading and accenting objects and for covering large areas with color very quickly.

Feature Watch:

- Look for a program that allows you to adjust the width and flow of the pixel spray and, if possible, allows you to spray with patterns in addition to solid colors.

Example:

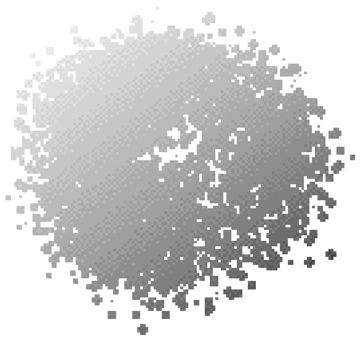


FIGURE 5-3: Airbrush Example

Shape Tools

This group of tools is responsible for drawing different types of basic geometric shapes from lines to rectangles. They include:

- The Line tool
- The Curve tool
- The Rectangle tool
- The Ellipse tool
- The Polygon tool
- The Fill tool

The Line Tool

The Line tool is used to draw straight lines at any angle. This tool usually draws lines in a single color using a variable width and style.

Both straight and diagonal lines are useful for creating objects with precise surfaces.

Feature Watch:

- Look for a program that allows you to draw connected lines with this tool. Sometimes this functionality is provided as a separate tool and sometimes it's included as part of the basic Line tool feature set.
- Virtually all lines created with this tool have square ends. If possible, look for a program that allows you to select rounded or arrow line ends in addition to square ends. This allows you to use this tool to label objects, etc.
- Look for programs that allow any lines you draw to be anti-aliased. This feature will allow you to draw smoother lines, which is especially useful for diagonal lines.

Example:

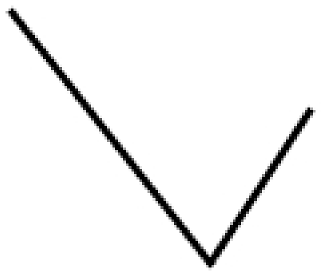


FIGURE 5-4: Line Example

The Curve Tool (a.k.a. Bezier Tool or Spline Tool)

The Curve tool is used to draw simple curves. The simplest implementations of this tool work with just two endpoints while the more advanced implementations allow you to draw curves with multiple endpoints. Like the Line tool, this option usually draws curves in a single color and using a variable width and style.

Curves are useful for rounding off the sharp edges on objects.

Feature Watch:

- Look for a program that allows you to manipulate the endpoints of the curve before you commit to drawing the curve. This feature is often called a *Spline* or *Bezier* tool and makes the process of drawing curves much easier and more precise.

Example:

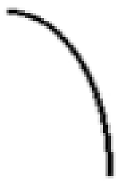


FIGURE 5-5: Curve Example

The Rectangle Tool (a.k.a. Box Tool)

The Rectangle tool lets you paint either filled or unfilled rectangles. This tool usually allows you to draw unfilled rectangles with variable line thicknesses. Some programs will also let you draw perfect squares using this tool.

Rectangles and squares are useful for creating all types of rectangular shapes.

Feature Watch:

- Look for a program that also lets you create filled or unfilled squares using this option.
- Look for a program that lets you draw rectangles with rounded edges.
- Look for a program that lets you draw filled or unfilled rectangles and squares using solid colors, patterns, and colored gradients.

Examples:

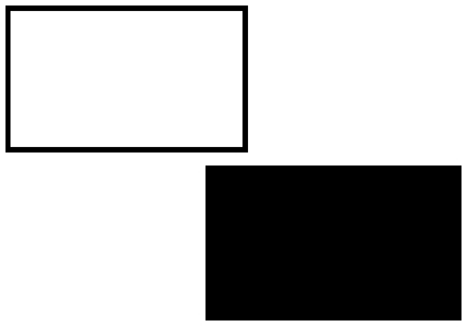


FIGURE 5-6: Filled and Unfilled Rectangle Example

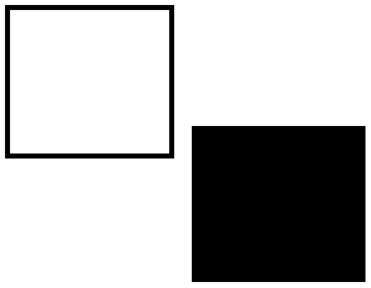


FIGURE 5-7: Filled and Unfilled Square Example

The Ellipse Tool (a.k.a. Circle Tool)

The Ellipse tool allows you to draw filled or unfilled circles and ellipses. Some programs also allow you to create rotated ellipses. This tool usually allows you to draw unfilled ellipses and circles with variable line thicknesses.

Ellipses and circles are useful for creating all types of round objects.

Feature Watch:

- Look for a program that lets you create filled circles and ellipses with solid colors, patterns, and colored gradients.
- Look for programs that allow any ellipses you draw to be anti-aliased. This feature will smooth out the edges of these shapes.

Examples:

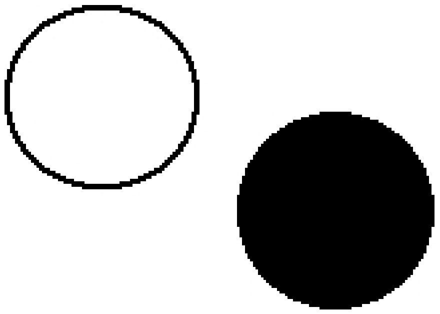


FIGURE 5-8: Filled and Unfilled Circle Example

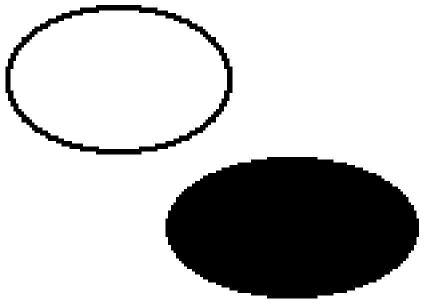


FIGURE 5-9: Filled and Unfilled Ellipse Example

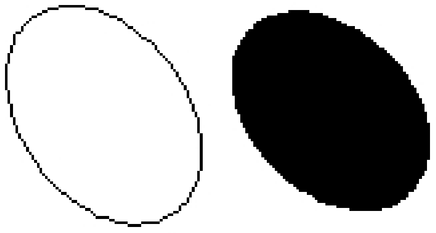


FIGURE 5-10: Filled and Unfilled Rotated Ellipse Example

The Polygon Tool

The Polygon tool lets you draw various types of filled and unfilled irregular shapes. Virtually all programs that provide this option will automatically complete the shape for you, even if you leave out the final connecting line. For example, if you draw three sides of a figure, the program will generate the fourth for you and complete the shape.

Polygons are useful for creating any object that has an irregular shape.

Feature Watch:

- Look for a program that lets you draw filled or unfilled rectangles and squares using solid colors, patterns, and colored gradients.
- Look for programs that allow any polygons you draw to be anti-aliased. This feature will allow you to smooth out the edges of irregular polygon shapes.

Examples:

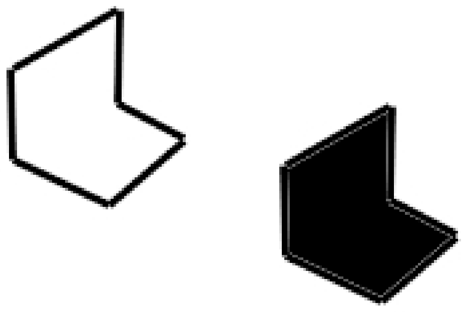


FIGURE 5-11: Filled and Unfilled Polygon Example

The Fill Tool (a.k.a. Paint Bucket)

The Fill tool is used for filling enclosed shapes with solid colors, patterns, or colored gradients. If a shape isn't completely closed, the contents of the area being filled can "leak out" into the surrounding areas. This also tends to happen if the boundary of the shape being filled is the same color as the color of the fill itself.

The Fill tool is extremely useful for filling in large areas of the screen with color very quickly.

Feature Watch:

- Look for a program that offers you a choice of solid and pattern fills. The program should allow you to select from these types of pattern fills:

  - **Dithered patterns**—These are patterns of closely grouped dots. In display modes with few colors available, using dithered patterns can simulate the presence of additional colors.
  - **Crosshatched patterns**—These are patterns formed by using various combinations of horizontal, vertical, and diagonal lines.
  - **Textured patterns**—These are patterns formed by using various textures or full-color image clippings. Textures can come from virtually any graphic source including photo-realistic images and line drawings.

NOTE: Most programs will let you edit existing fill patterns as well as let you create your own from scratch.

- Look for a program that also supports *color gradient* fills. A color gradient is a series of colors that gradually fade from light to dark. When evaluating this feature in a painting program be sure to look for these gradient fill options:
  - **Linear fills**—Fills in an area using a linear color gradient. Straight fills may be vertically, horizontally, or diagonally oriented. Many programs allow you to control the exact angle of the fill while others predefine them for you.
  - **Radial fills**—Fills in an area using a circular color gradient. These fills produce a pronounced and rounded, 3D-like effect. To further enhance this feature, many programs allow you to control the exact angle of how the fill is applied.
  - **Contoured fills**—Works in a similar fashion to the Radial fill effect; however, contoured fills take into account the actual shape of the object being filled. Contoured fills tend to produce beveled 3D-like effects. To further enhance this feature, many programs allow you to control the exact angle of how the fill is applied.

NOTE: Some programs offer the ability to roughen the quality of the fill. This is useful for certain types of visual effects such as creating textures.

NOTE: Gradient fills are very useful for creating many types of special graphic effects. If a particular program doesn't provide a gradient fill option, find another that does.

Examples:

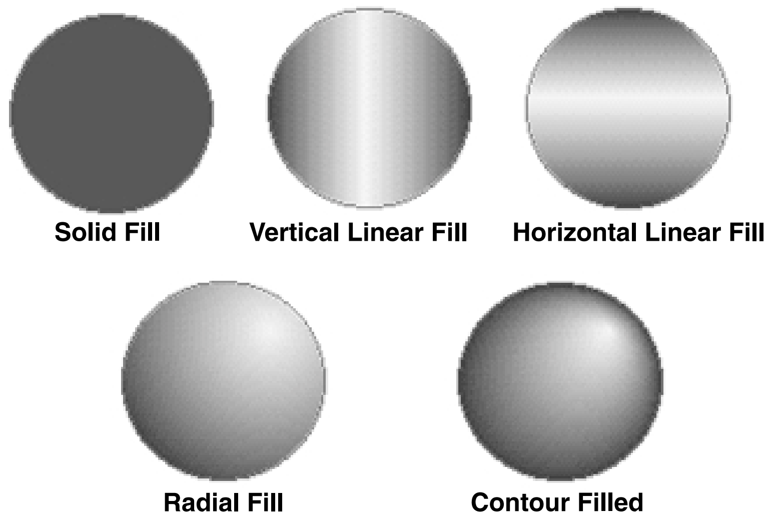


FIGURE 5-12: Fill Examples

Block Tools

This group of tools is responsible for selecting and manipulating various sections of your image. They include:

- The Selection tool
- The Lasso tool

The Selection Tool (a.k.a. Brush Capture)

The Selection tool allows you to select a rectangular portion of an image and temporarily store it for further manipulation. This rectangular selection is called a *block*. All painting programs automatically copy the captured screen region into a hidden memory buffer. In a Windows program, the block is usually copied over to the Windows Clipboard.

The Selection tool is useful for grabbing rectangular sections of the screen where they can be used as custom brushes and for producing special effects. However, the most common use of the Selection tool is for making copies of objects.

Feature Watch:

- Look for a program that provides these features and transformations after you make a selection:
  - **Cut**—Cuts or removes a block from the visible screen. In most programs, the block isn't actually removed but rather stashed to a temporary memory buffer. In Windows programs, a cut block is copied to the Clipboard

where it can usually be pasted back on the screen. The contents of the buffer or Clipboard are replaced with new image data each time you cut a new selection.

- **Copy**—Copies or duplicates a block to the visible screen. Many programs will move the copied block to a temporary buffer while Windows programs will copy the block to the Clipboard. Once a block has been copied, it can usually be pasted back on the screen. The contents of the buffer or Clipboard are replaced with new image data each time you copy a new selection.
- **Paste**—Pastes a block that has been previously cut or copied to a buffer or the Clipboard back on the screen. Since the contents of the buffer or the Clipboard aren't erased until a new selection has been cut or copied, you may paste blocks to your heart's content. Some programs allow you to control how a block is pasted back on the screen. There are several options available but look specifically for a program that allows you to paste blocks *opaquely* and *transparently*. Blocks pasted opaquely will overwrite the background image with their contents. Meanwhile, blocks pasted transparently will allow the background image to show through certain parts of the block.

NOTE: Cut, Copy, and Paste functions are considered to be standard features in any painting program and are indispensable to the graphics artist. Don't use a program if it doesn't support at least some of these features.

- **Resize**—Resizes (stretches or shrinks) a block. Many programs allow you to interactively control the size of the block with the mouse while others force you to manually type values into a dialog box to resize the block. Some programs also break out these options into separate Stretch and Shrink operations.
- **Rotate**—Rotates a block along a given axis. Some programs allow you to interactively rotate a block through all 360 degrees using the mouse while other programs only allow blocks to be rotated at 90-degree intervals using menu commands.
- **Bend**—Bends a block from its center to the left, right, top, or bottom. Most of the programs that provide this feature will allow you to interactively control the bending with the mouse.
- **Shear**—Skews or stretches a block from a specified anchor point. Many of the programs that offer this feature will allow blocks to be interactively sheared to the left, right, top, and bottom using the mouse.
- **Half**—Reduces a block by half along its horizontal and vertical axes. This is similar to the Resize option except the block reduction is done

proportionally. For example, a block that is 32x32 pixels in size will be 16x16 pixels after it is halved.

- **Double**—Enlarges a block by two times its size along its horizontal and vertical axes. This is similar to the Resize option except the enlargement is done proportionally. For example, a block that is 32x32 pixels in size will be 64x64 pixels after it is doubled. Look for a program that allows you to perform this operation interactively using the mouse.
- **Flip**—Flips a block along its axis in mirror image fashion. Most programs allow you to choose whether a block is flipped horizontally, from left to right or right to left, and vertically, top to bottom or bottom to top.
- **Single color**—Discards all the color information contained in a block and fills in the block area with the current drawing color. This feature is usually used to make large drawing brushes.
- **Load block**—Retrieves a block from disk and places it into the copy buffer or Clipboard for further use and manipulation.
- **Save block**—Saves a block to disk for future use. Most programs save blocks in proprietary file formats but will occasionally use standard file formats to save their block data.

Examples:

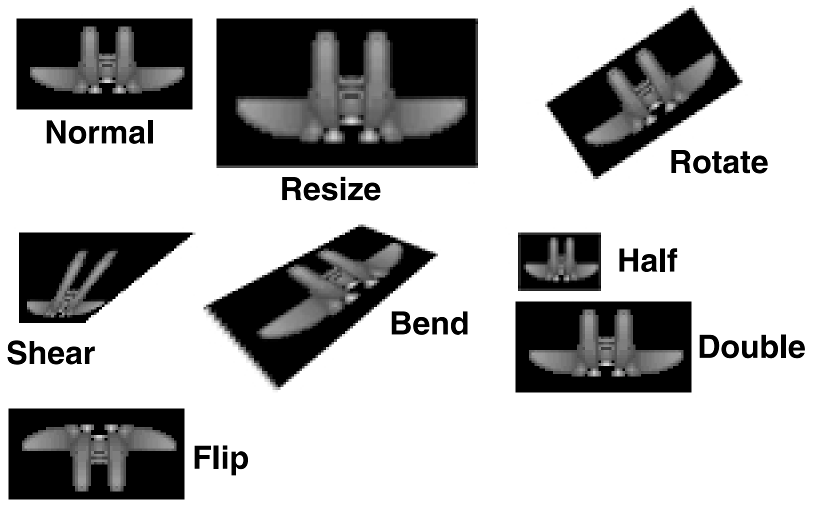


FIGURE 5-13: Resize, Rotate, Bend, Shear, Half, Double, and Flip Examples

NOTE: There's one major difference between how the Selection tool works in DOS and Windows painting programs. Windows programs typically support what are known as *active* selection tools. This means that once you make a selection, the selection is preserved until it's manually deselected or disabled by another program operation. DOS-based painting programs typically don't offer this capability. Active selections are far more flexible for manipulating image blocks as they allow for you to perform successive manipulations without having to continually reselect it.

The Lasso Tool (a.k.a. Block Carve or Freehand Selection Tool)

The Lasso tool allows you to select an irregular portion of an image and temporarily store it for further manipulation. Despite the fact that the selection appears to be non-rectangular, it is still referred to as a *block*. All painting programs automatically copy the captured screen region into a hidden memory buffer. In a Windows program, the block is usually copied to the Clipboard.

The Lasso tool is useful for grabbing non-rectangular sections of the screen. For example, you can use this tool to trace the outline of a circle or another complex shape and then copy it, cut it, paste it, or even paint with it.

Feature Watch:

- All programs that support the Lasso tool can usually apply the same block transformations supported by the Selection tool.
- Make sure the program supports a Lasso tool that can make *transparent* image selections. These are selections where the background shows through the foreground. It can enable you to produce some interesting visual effects as well as give you more control over the items you are selecting and manipulating.

NOTE: Lasso tools under Windows are often active as defined under the Selection tool description.

Navigation Tools

This group of tools lets you easily navigate across different sections of your image. They include:

- The Zoom tool
- The Navigator tool

The Zoom Tool (a.k.a. Magnifying Glass or Fatbits)

The Zoom tool lets you magnify any area of an image.

The Zoom tool is useful for doing close-in, pixel-by-pixel editing of images. When working with this tool, you have full and precise control over every pixel in the portion of the image area being magnified. Because of this, it's probably the single most important tool in your graphics toolbox.

Feature Watch:

- Look for a program that supports multiple levels of magnification, i.e., 2, 3, 4, 6, and 8 times the original size of the image. In practice, a magnification level between 4 and 8 times is the most useful. Most programs tend to only offer one or two levels of magnification, however.
- Make sure the program you'd like to use allows you to use all of the available painting tools while working with the magnification tool. Without this ability, you'll need to constantly switch back and forth between tools, thus wasting time and severely affecting your overall productivity.
- Look for a program that lets you see the magnified version of an image alongside the actual sized view (as in Figure 5-14). This way you can visualize the changes you make as they happen.
- Look for a program that allows you to toggle the *magnification grid* on and off. The magnification grid inserts grid lines between magnified pixels to help you see distinctions between pixels of the same color. While this feature is often helpful, it can also become distracting; thus, you should have the ability to turn it off.
- Look for a program that allows you to use both the mouse and arrow keys to move through a magnified image. This saves time since the keyboard can often be faster for scrolling operations.

Example:

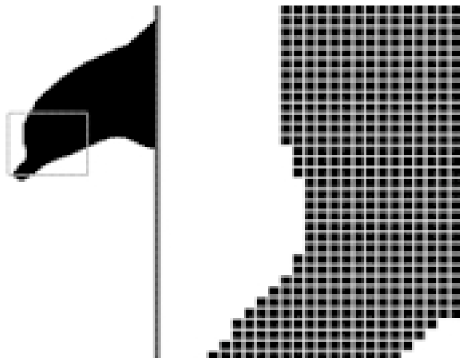


FIGURE 5-14: Zoom Tool Example

The Navigator Tool (a.k.a. Grabbing Hand Tool)

The Navigator tool lets you access different sections of the image you're currently working on. This tool is useful for moving around and viewing different sections of an image while drawing.

Feature Watch:

- Look for a program that allows you to visually select the area you want to access. Typically, most programs can show a small preview of the entire screen and then use a small, movable window to zero in on the area of the screen that you want to see.

Color Tools

This group of tools lets you control, define, and modify the color information contained in your image. They include:

- The Eye Dropper tool
- The Palette Selector tool

The Eye Dropper Tool (a.k.a. Pipette Tool)

The Eye Dropper tool allows you to obtain color information from any pixel within an image.

The Eye Dropper tool can be used to quickly change the current painting color by simply clicking on any pixel within an image. For example, if the current drawing color is set to red, you can move the Eye Dropper tool over to a part of the image that contains green and then change the painting color to green.

The main use of the Eye Dropper is to quickly swap drawing colors without forcing you to fumble around your painting program's color palette.

Feature Watch:

- None. The Eye Dropper tool functions the same in almost every painting program available.

NOTE: Since this tool is such a time saver, don't consider using any painting program that doesn't include one.

The Palette Selector tool (a.k.a. Palette Tool)

The Palette Selector tool allows you to create and modify color combinations for use in your color palette. The number of colors available to you will depend on your current display mode settings and the capabilities of your system. Most programs will allow you to specify color selections using either the RGB (red-green-blue) color model or the HSV (hue-saturation-value) color model.

The Palette Selector tool gives you full control over the colors used in your images. With this tool you can define and redefine both color palettes and color gradients.

NOTE: There is a major difference between how color values are specified between DOS and Windows systems. See Chapter 8 for more information on these differences.

Feature Watch:

- Look for a program that supports these features:
  - **Spread**—Creates a gradient, or a color spread, between two different colors in the current color palette. Most programs let you define a starting color and an ending color for the gradient. The Spread function will then generate all of the color shades that fit between these two colors. For example, to create a gradient that contains only grays, you would make the starting color black and the ending color white or vice versa. The Spread function would then compute all of the intermediate shades of gray that fit between black and white. The smoothness of the transition between the colors depends on the number of color entries that separate the start and ending colors you select. More colors between them produce smoother gradients while fewer colors produce coarser gradients. This function is also sometimes referred to as a *color ramp*. This function is primarily used for grouping colors with similar shades together in the color palette.
  - **Copy**—Copies the value of one color in your color palette to another position in the color palette. This function is useful for making quick adjustments to your palette.
  - **Swap**—Swaps, or exchanges, the positions of two different colors in your palette. This function is useful for rearranging individual colors in your color palette.
  - **Gradient**—Works much like the Swap function but is specifically used to create and manage color gradients used by the Fill tool described earlier in this chapter. Some programs will limit you to gradients of only 16 shades while others will let you use the entire palette for a gradient.
  - **Load**—Retrieves a saved color palette from disk. Look for a program that lets you load color palettes saved in the Microsoft Palette (.PAL) format.
  - **Save**—Saves the contents of the current color palette to disk for later use. Look for a program that lets you save your palette data in the Microsoft Palette (.PAL) format, as this will make your color palette definitions compatible with many other programs.
  - **Undo**—Erases any changes or additions you might have made to the current color palette.

- **Restore**—Restores the current palette to its original, unmodified state. Many programs predefine the color palette with their own definitions. This function returns the color palette to the program's default palette.

Image Processing Tools

This group of tools allows you to apply different types of color enhancements to your image. They include:

- The Brighten tool
- The Darken tool
- The Smooth tool
- The Smear tool
- The Translucency tool

The Brighten Tool (a.k.a. Dodge Tool)

The Brighten tool lets you brighten the colors contained in an image. The Brighten tool is useful for increasing the color intensity of an image or image area. For example, using this tool on an area that contains dark gray will produce light gray. This tool is very useful for adding highlights to objects.

Feature Watch:

- Look for a program that allows you to brighten up selections as well as the entire image.

The Darken Tool (a.k.a. Burn Tool)

The Darken tool lets you darken the colors contained in an image.

The Darken tool is useful for reducing the color intensity of an image or image area. It's the exact opposite of the Brighten tool. For example, using this tool on an area that contains light red will produce dark red.

This tool is very useful for adding dark accents to objects.

Feature Watch:

- Look for a program that allows you to darken selections as well as the entire image.

The Smooth Tool (a.k.a. Average)

The Smooth tool lets you soften hard lines by reducing the amount of contrast between two adjoining colors. This tool works best on images with large gradients defined in the color palette as they enhance the smoothing effect. The Smooth tool is very useful for removing rough edges from the surfaces of various objects.

Feature Watch:

- Look for a program that allows you to use all drawing tools (i.e., brush, rectangles, block, etc.) with this feature.

Example:

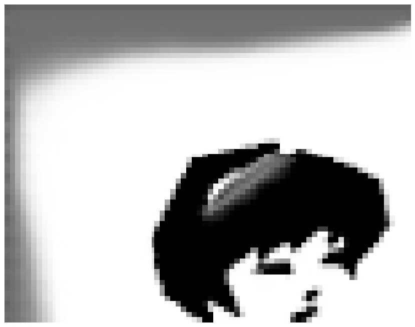


FIGURE 5-15: Smooth Tool Example

The Smear Tool (a.k.a. Smudge or Blend Tool)

The Smear tool smears the colors of an object as you paint over them. The effect it produces is similar to smearing paint with your fingers. The Smear tool is useful for creating certain types of shading and blending effects.

Feature Watch:

- Look for a program that allows you to use all drawing tools (i.e., brush, rectangles, block, etc.) with this feature.

Example:

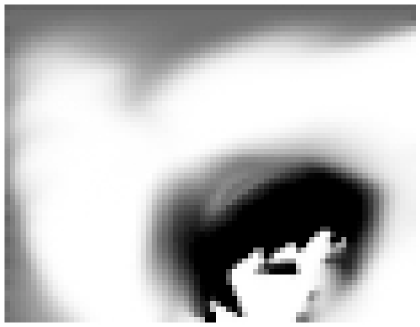


FIGURE 5-16: Smear Tool Example

The Translucency Tool

The Translucency tool operates as a toggle. It produces a transparent effect as you draw, allowing the background of the image to show through to varying degrees. Most programs let you adjust the transparency level, usually by specifying a percentage ranging from 0% (opaque) to 100% (completely transparent). For example, say you were drawing with white over a brown object while the Translucency tool was active. If the transparency level were set to 75%, the resulting color would be equal to 75% of the drawing color, or equivalent to the color beige.

The Translucency tool is useful for created muted color effects for when you want to render an object visible but not necessarily make it the main focus of the image.

NOTE: The concept of translucency is explained in greater detail in Chapter 7.

Feature Watch:

- Look for a program that allows you to use all drawing tools (i.e., brush, rectangles, block, etc.) with this tool.
- Look for a program that allows you full control over the transparency level setting.

Example:

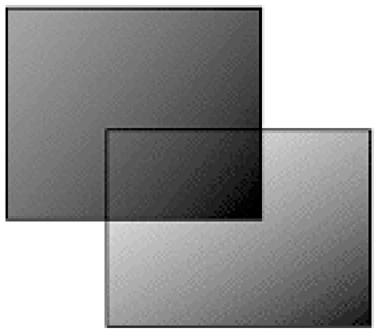


FIGURE 5-17: Translucency Tool Example

NOTE: General-purpose image processing is one area where true color painting programs have the advantage over palette-based painting programs. Many of these programs will offer more tools than those mentioned here.

Special Effects Tools

This group of tools allows you to apply different types of special effects to your image. They include:

- The Stencil tool
- The Anti-alias tool
- The Colorize tool
- The Shade tool

The Stencil Tool (a.k.a. Screen Mask)

The Stencil tool lets you create *stencils*, or protected areas of color within the current image. Stencils work like masking tape, that is, any area that contains colors that are stenciled can't be painted over with other drawing colors.

Stencils are extremely useful for experimenting with different effects on an image without having to worry about ruining its contents.

Feature Watch:

- Look for a program that allows you to specify the individual colors to stencil and that provides options to save and load the stencils you create for future use.

NOTE: Stencils are largely palette independent. For example, if you stenciled a particular shade of blue in one palette, it will remain stenciled in another image as long as that same shade of blue exists in the new image's color palette.

Example:

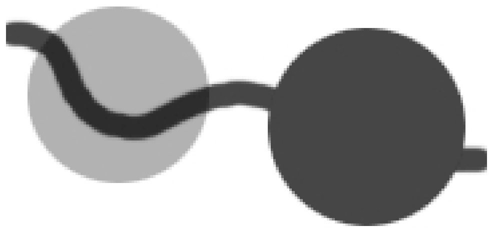


FIGURE 5-18: Stencil Example

The Anti-alias Tool

The Anti-alias tool operates as a toggle. It minimizes the impact of screen aliasing by reducing the amount of contrast between two adjoining colors. Essentially, it's analogous to a version of the Smooth tool that works with specific drawing functions. Like the Smooth tool, the more colors present in the palette, the better the resulting anti-aliasing effect is.

The Anti-alias tool is useful for removing rough edges from the surfaces of different objects and particularly effective for text, especially at low screen resolutions.

Feature Watch:

- Look for a program that offers more than one anti-aliasing algorithm. Some algorithms produce better results on certain types of objects than others.
- Make sure the program allows you to apply anti-aliasing to every drawing tool available. This gives you maximum flexibility.

Examples:

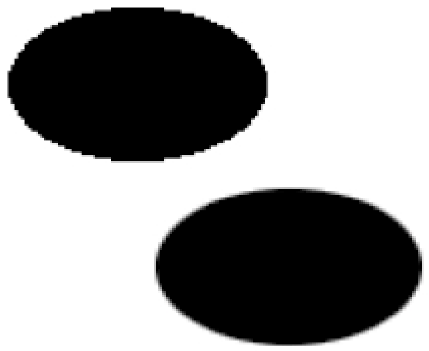


FIGURE 5-19: Normal Ellipse (aliased) vs. Anti-aliased Ellipse

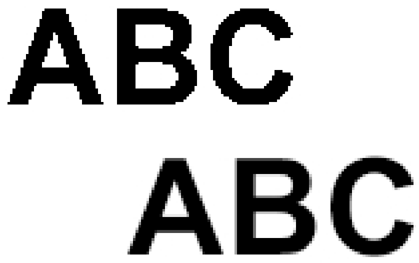


FIGURE 5-20: Normal Text (aliased) vs. Anti-aliased Text

The Colorize Tool (a.k.a. Tint)

The Colorize tool adds the current painting color to the current image while preserving the value (or intensity) of the original image color.

The Colorize tool is useful for adding color to monochrome (black and white) and gray scale images. It's also useful for replacing ranges of similar colors with ranges of a different color while maintaining the original color intensity of the object. For example, you can use this tool to replace a gradient of 16 grays with 16 reds, provided both sets of colors have the same level of color intensity. The new colors in the gradient will still retain their original brightness.

NOTE: For more information on color intensity, see Chapter 7.

NOTE: This tool can be a real time saver when it comes to recoloring objects very quickly. For example, with this tool, you can change the green color scheme of a tank object to brown without affecting the object's overall appearance.

Feature Watch:

- Look for a program that allows you to colorize image blocks as well as the whole image.
- Look for a program that allows you to use all drawing tools (i.e., brush, rectangles, block, etc.) with this feature.

The Shade Tool

The Shade tool is used to create subtle shading effects within your images. It works by progressively sampling and darkening the current color. The Shade tool is especially useful for adding shading to large screen objects such as title screen logos or background scenery.

Feature Watch:

- Look for a program that allows you to use the Shade tool with any size brush for maximum control.

NOTE: The Shade tool works best when there are many similar colors defined in your palette; otherwise, the impact of the shading effect is lost. Some programs also only support shading effects when gray or white is selected as the current painting color.

Other Tools

This group of tools enables you to correct mistakes, erase entire images, create precise drawings, and easily apply text to your image. They include:

- The Grid tool
- The Eraser tool
- The Clear tool
- The Undo tool
- The Text tool

The Grid Tool

The Grid tool modifies the behavior of the different drawing tools. When activated, the Grid tool applies an invisible grid to the image area. All tools are then constrained to draw only within the coordinates specified by the grid.

The Grid tool is very useful for producing precise drawings and is essential for creating the constraining grid boxes needed by sprites and background objects.

Feature Watch:

- Look for a program that allows you to adjust the grid spacing by both horizontal and vertical pixel values.
- Look for a program that allows you to use all drawing tools (i.e., brush, rectangles, block, etc.) with this feature.

Example:

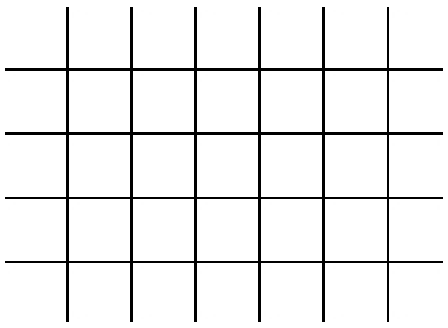


FIGURE 5-21: Grid Example

The Eraser Tool

The Eraser tool allows you to selectively erase areas of the screen. It replaces the contents of the foreground with the currently selected background color. Essentially, it works like the Brush tool with a fixed brush width that only paints with the background color.

Example:

FIGURE 5-22: Eraser Example

The Clear Tool (a.k.a. Erase)

The Clear tool allows you to erase the contents of the entire screen. It usually replaces what's on the screen with the current background color.

The Clear tool comes in handy when you want to erase the contents of a screen and completely start your drawing over from scratch.

Feature Watch:

- Look for a program that prompts you to confirm this operation before it erases the contents of the screen. After all, there's nothing worse than activating this tool by accident and losing your masterpiece forever!

The Undo Tool

The Undo tool allows you to undo your last painting action. Because of this, it'll quickly prove to be one of the most useful tools you have at your disposal.

The Undo tool is extremely useful for correcting mistakes that you make. If you activate it, the contents of the screen will be fully restored to the exact state it was in prior to your last change/mistake. For example, say you draw a circle in the wrong place on the screen and accidentally ruin your image. With the Undo tool, you can restore your image back to how it looked before you added the circle.

Feature Watch:

- Look for a program that has what's called an "undoable," or reversible, undo tool. This feature lets you undo the undo operation! For example, say you draw a red rectangle and then decide to undo it. With a Reversible Undo tool, you can bring back the red rectangle. This feature can also prove very useful when it comes to testing how different sprite cells will look when animated.

NOTE: A painting program without an Undo function is totally useless. No matter how good or experienced you are, you will make plenty of mistakes when drawing arcade game graphics. An Undo tool can help minimize the impact of most of them.

NOTE: Some programs also have a feature called an *undo history*. This feature allows you to repeat or undo certain operations that were made several operations in the past. So, in effect, you could reproduce certain changes you made to an image in the past.

Example:

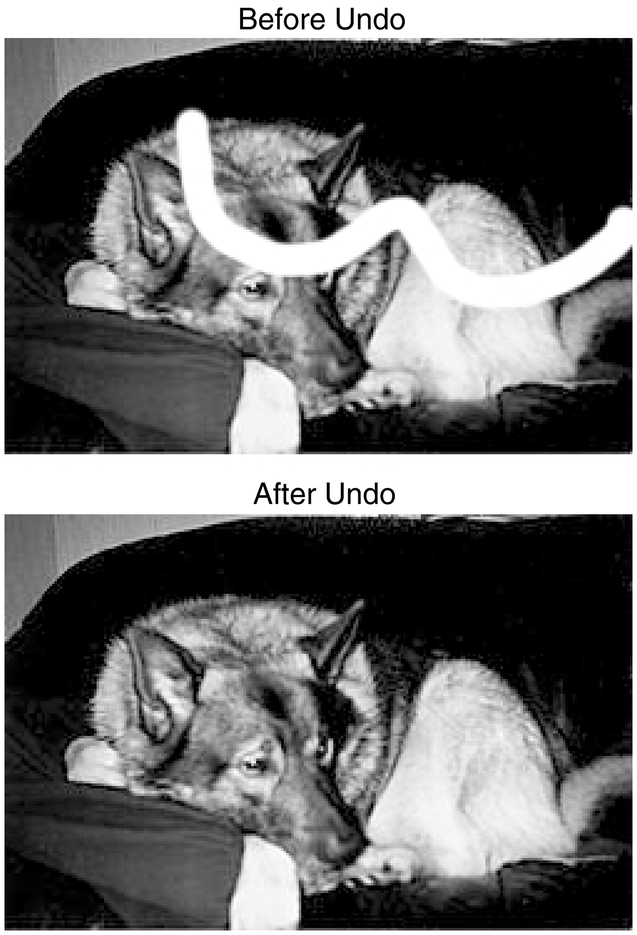


FIGURE 5-23: Undo Example

The Text Tool

The Text tool lets you add and edit text lines or entire blocks of text in a variety of *fonts*, or type styles, to an image. In most programs, this tool will render text in the current painting color. The Text tool is useful for adding text for image captions, screen menus, and game status indicators.

Feature Watch:

- Make sure a program has a Text tool that supports multiple sizes. Windows programs usually let you use any installed Windows TrueType font in any size supported by the system. However, DOS programs usually restrict you to only a few predetermined point sizes. If using a DOS painting program, be sure to look for a program that allows you to select text from 8-point, 16-point, 24-point, 36-point, and 48-point, if possible.

- If using a DOS painting program, make sure it supports GEM or ZSoft font formats as there are large numbers of these fonts available.
- Look for a Text tool that supports **bold**, *italic*, and underline styled text in addition to normal text.
- If possible, look for a program that allows you to control or adjust text attributes such as:
  - **Leading**—*Leading* is a measurement of the vertical space between lines of characters. Leading can be used to adjust the balance and legibility of text on the screen. Lines with too little leading can seem cramped and crowded, while lines with too much leading can seem too open. Many game designers fail to take leading into account when they place text on the screen. Poor leading can make information difficult to read and find.
  - **Kerning**—*Kerning* is a method of reducing the space allotted to one or both sides of a character to make it fit more comfortably between its neighbors. Kerning is frequently used to improve the legibility of text.
  - **Tracking**—*Tracking* is a measurement of the overall letter spacing over a line. Adjusting the tracking of a line can also improve its legibility.
  - **Weight**—A font's *weight* is a measurement of the vertical thickness of the individual characters in a font. Font weight is specified according to several grades: *extra-light*, *light*, *book*, *medium*, *bold*, *extra bold*, and *black*. Fonts get darker and heavier in appearance as their weight increases. Be aware that not all fonts support all of these weights.
- Look for a Text tool that lets you place text anywhere on the screen and doesn't restrict you to character boundaries. Some older software, especially DOS programs, tend to do this.
- Look for a Text tool that supports both *proportional* and *monospaced* fonts. In fonts that are proportional, each character is given only as much horizontal space as it needs. For example, in a proportional font the letter "I" doesn't take up as much spaces as the letter "W." Proportional fonts are very popular for text-heavy applications because their characters are easy to distinguish from each other. Meanwhile, monospaced fonts are commonly used for displaying information that must line up on-screen in a particular way, such as source code or a game's high score table. However, they are not very good for displaying large amounts of connected text, which is commonly found in game help screens and on-screen instructions. This is because each character in a monospaced font is surrounded by a fixed amount of white space which makes their appearance seem uneven.

NOTE: Most DOS fonts are of the monospaced variety, whereas TrueType fonts tend to be both.

- Look for a Text tool that gives you basic text editing features such as backspacing, forward deletion of characters, cursor key movement, and mouse controlled text insertion.
- Look for a Text tool that supports left, right, and centered text alignment.
- Look for a Text tool that supports anti-aliasing as this produces smoother looking text, especially at lower screen resolutions. Just be careful when using this feature.

Examples:

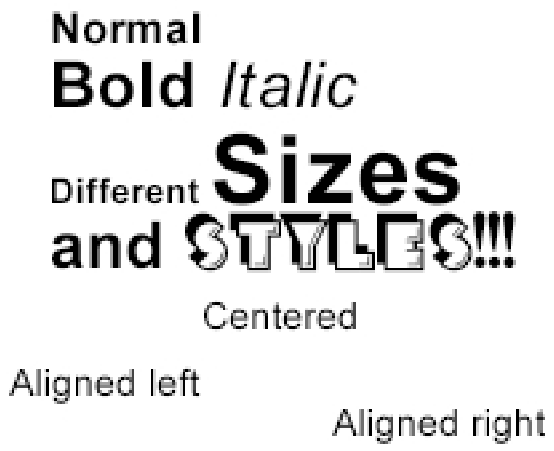


FIGURE 5-24: Text Tool Example

Miscellaneous Features

These are features that every painting program should provide. They include:

- Standard file formats
- Multiple display mode support
- Multiple work screen support
- Keyboard shortcuts
- Coordinate tracking

Standard File Formats

Any painting program you use should be fully compatible with all industry standard file formats, especially if you plan to exchange your graphics with different programs, systems, or development tools. A word of warning: not all programs will both load and save every possible file format. This shouldn't pose a problem, however, as long as the program you're considering using is compatible with one or more of the formats described in Table 5-2.

TABLE 5-2: Industry Standard File Format Support

Graphics File Format	*Comments*
IFF/LBM	The program should be able to load and save this format because it's a well-established PC graphics format (*Deluxe Paint IIe*).
GIF 87a	The program should at least be able to load and save files in this format, as it's practically a universal graphics standard. Support for the GIF 87a is essential since it ensures full backward compatibility with older graphics applications.
GIF 89a	The program should be able to load and save this format, as it's a universal graphics standard.
Macintosh PICT	It would be nice for a program to at least be able to load files in this format, but it isn't essential.
PC Paintbrush PCX	The program should be able to load and save this format, especially if you develop games for DOS because it's the standard graphics format on that platform.
PNG	It would be nice for a program to at least be able to load and save files in this format, but it isn't essential to do so at this point in time.
Targa TGA	Not a common graphics format so its support isn't required or expected.
Windows RGB BMP	The program must be able to load and save this format because it's the standard Windows graphics format.
Windows RLE BMP	The program must be able to load and save this format because it's the standard Windows graphics format.

NOTE: For more information on each of these graphic file formats, please refer to Chapter 3.

Multiple Display Mode Support

You should look for a program that supports all industry standard screen resolutions (i.e., 320x200, 640x480, and 800x600) and color depths (i.e., 8 bit, 16 bit, and 24 bits). This mainly affects DOS-based graphics software since historically DOS programs have required a separate video driver for each type of graphics card and for each display mode.

Table 5-3 summarizes which display modes to look for when evaluating a DOS-based painting program.

Most Windows programs, on the other hand, don't have to worry too much about this issue. That's because Windows will automatically work with whatever display modes your video hardware supports. The only exception to this rule occurs when a particular program isn't designed to take advantage of certain display modes, i.e., a program that limits itself to 8-bit color palette, etc. The program's documentation will tell you if this is the case.

NOTE: Please be aware that 16-bit and 24-bit color depths aren't typically supported by most DOS painting programs since these display modes weren't common when most of these programs were originally written.

TABLE 5-3: Essential Display Modes (DOS)

Screen Resolution	*Color Depth*	*Comments*
320x200	8 bits/256 colors	Assume every DOS-based painting program is compatible with this display mode.
320x200	24 bits/16.7 million colors	Only a handful of DOS-based painting programs support this mode and only when using a third-party VESA driver on compliant SVGA video hardware.
320x240 and other Mode X progeny	8 bits/256 colors	It's important to understand that only a handful of DOS-based painting programs actually support these display modes and then usually only when patches or other modifications are applied to them. Access to these display modes isn't essential but can be helpful, especially when trying to match your artwork's aspect ratio with that of the target display mode.
640x480	8 bits/256 colors	Most DOS-based painting programs are compatible with this display mode. However, their video drivers might not work with your particular graphics hardware. If this is the case, a program such as SciTech's *Screen Display Doctor* utility can ensure compatibility with this display mode.
640x480	24 bits/16.7 million colors	Only a handful of DOS-based painting programs support this mode and only when using a third-party VESA driver on compliant SVGA video hardware.
800x600	8 bits/256 colors	Most DOS-based painting programs are compatible with this display mode. However, their video card drivers might not work with your particular graphics hardware. If this is the case, a program such as SciTech's *Screen Display Doctor* utility can ensure compatibility with this display mode.

Screen Resolution	*Color Depth*	*Comments*
800x600		Only a handful of DOS-based painting programs support this mode and only when using a third-party VESA driver on compliant SVGA video hardware.

NOTE: Some programs, particularly those available for Windows, allow you to define screen windows of various sizes, but all programs are still restricted to working within one of the screen resolutions referred to in this table.

Multiple Work Screen Support

The best painting programs provide spare screens for you to work with. For example, you can use one screen to experiment with different types of effects and the other to actually hold the final results. Or imagine how useful it would be to have multiple screens available to store different images and copy objects between them. In such cases, having access to work with multiple screens can really be useful.

Windows-based painting programs usually let you open as many new screen windows as free memory will allow. However, because DOS is particularly bad at managing memory, this feature is far less common under DOS than it is under Windows. In fact, you'll be lucky to find a DOS painting program that lets you access more than two screens at a time. These programs do exist, but they're very rare. In any case, make sure that any painting program you're considering, whether it runs under DOS or Windows, allows you to open up multiple work screens.

Keyboard Shortcuts

In any program, keyboard shortcuts are likely to save you time, especially when dealing with repetitive tasks. Well, painting programs can benefit from keyboard shortcuts as much as any application, if not more. Therefore, make sure that any program you're considering, whether it runs under DOS or Windows, offers plenty of keyboard shortcuts.

Table 5-4 lists all of the common operations that should have keyboard shortcuts associated with them. Look for these in any program that you evaluate.

TABLE 5-4: Suggested Keyboard Shortcuts for Common Painting Program Operations

Program Operation	*Comments*
Block copying	Occurs very frequently while designing arcade game graphics so look for a keyboard shortcut that's convenient to access and an established application standard, i.e., Ctrl+C or Shift+C.
Block pasting	Occurs even more frequently than block copying when designing arcade game graphics so look for a keyboard shortcut that's convenient to access and an established application standard, i.e., Ctrl+V or Shift+V.
Block cutting	Occurs quite often when designing arcade game graphics. Typically, block cutting is used to swap the location of objects on the screen. Therefore, it's important for the painting program to support an established application standard, i.e., Ctrl+X or Shift+X.
Loading images	If you're working with many different images, having access to a keyboard shortcut for this function will save you lots of time. Look for a logical shortcut like Alt+L or F9.
Saving images	One of the cardinal rules of working with computers is to save your work frequently. Power fails and systems die. So, if you're working on your next masterpiece, having access to a keyboard shortcut for this function will save you lots of time and worry. Look for a logical shortcut like Alt+S or F10.
Scrolling	When you work with high-resolution images, you'll notice that most programs don't let you see the whole image at once. Therefore, you'll need to scroll in order to view different sections of it. And if you spend any time editing your image with the Zoom tool, you'll find that scrolling with the mouse isn't all that fast or practical. Also, look for keyboard shortcuts that let you use the arrow keys to navigate the screen in fine pixel increments or the PgUp and PgDn keys to scroll the screen up or down, respectively.
Toggling anti-aliasing	Anti-aliasing improves the appearance of many drawing tools. Make sure any program you evaluate provides a keyboard shortcut to toggle it on and off as needed, i.e., Alt+A.
Toggling colorizing	Colorizing can help you to create some very interesting effects. Because this feature can get in the way at times, you'll also want the ability to toggle this feature on and off as needed. Look for a logical keyboard shortcut that allows you to do this easily, i.e., Alt+T.
Toggling the grid	Grids are useful for creating precise drawings and you'll use this tool often. Because this feature can get in the way at times, you'll also want the ability to toggle this feature on and off as needed. Look for a keyboard shortcut that allows you to do this, i.e., Alt+G.

Program Operation	*Comments*
Toggling the stencil	The ability to "mask off" different areas or colors on the screen can prove to be invaluable, especially when you want to experiment without risking your work. Because this feature can get in the way at times, you'll also want the ability to toggle this feature on and off as needed. Look for a keyboard shortcut that allows you to do this, i.e., Alt+M.
Undoing	The Undo tool is probably your single most powerful drawing tool and you'll wind up using it quite a bit. Therefore, look for a logical keyboard shortcut for this tool such as Ctrl+Z or Alt+U.
Zooming	Once you get serious about creating arcade game graphics, you'll spend most of your time editing images using the Zoom tool. As a result, you'll definitely want the ability to quickly access this tool. You'll also want a program to allow you to scroll while "zoomed." Look for simple and logical keyboard shortcuts like Alt+Z or Z to activate your painting program's Zoom Tool.

Coordinate Tracking

When activated, this option displays the X and Y coordinates for any pixel on the screen. This feature is useful for recording the starting and ending points of graphic objects and comes in handy when you need to measure the horizontal and vertical dimensions of a particular object.

NOTE: This option is not the same as a ruler and shouldn't be used as or confused with one.

Example:

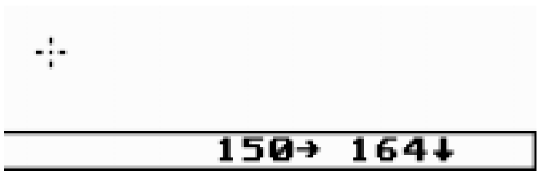


FIGURE 5-25: Coordinate Tracking

NOTE: Be sure to look closely at Chapter 6 for specific reviews and recommendations of painting programs that support most if not all of the features and tools described here.

Essential Screen Capture Utility Features

All screen capture programs are not alike. However, all of these programs share a common set of core features. This section of the chapter examines the features that a screen capture utility must have to be useful:

- Capture flexibility
- Common file format support
- Ease of use

Capture Flexibility

Any screen capture utility needs to offer several methods for capturing a given screen. Years ago, Windows wasn't very popular and it was sufficient for such programs just to capture the entire contents of the screen. However, this is no longer the case. Today's screen capture utilities now have to be more flexible in order to work effectively with today's DOS and Windows systems. Therefore, any screen capture utility worth its salt should support the following image capture features:

- Full screen capture
- Active window capture
- Region capture
- DOS screen capture
- DirectX capture

Full Screen Capture

This feature allows you to capture or save the contents of the entire display screen regardless of the current color depth or screen resolution.

Active Window Capture

This feature allows you to capture the contents of the currently active window while ignoring the contents of the rest of the display screen. It should be able to capture the contents of the active windows regardless of color depth or resolution.

This is probably the single most important screen capture option, since most Windows-based games run within a single screen window.

Region Capture

This feature allows you to capture any user-defined screen region and isn't specifically limited to capturing certain windows or predefined areas of the current screen. When this feature is available, the screen capture utility usually provides some sort of mechanism for selecting the region to be captured.

This feature can be a time saver, particularly when you're interested in capturing a specific portion of a screen and don't want to take the extra step of capturing a screen and editing it in another program.

DOS Screen Capture

This feature allows you to capture the contents of a DOS screen or console window and is extremely useful for capturing old DOS game and application screens.

NOTE: Not all programs provide this feature and even those that do aren't always able to capture every DOS game screen due to various technical issues.

DirectX Capture

This feature allows you to capture the screens of games that use Windows' DirectX technology. Because DirectX uses special tricks, most ordinary screen capture programs will fail when attempting to capture such screens. This feature is extremely important given the fact that most new Windows games use DirectX and their screens are difficult, if not impossible, to accurately capture otherwise.

Common File Format Support

As you'll often need to manipulate the images you capture, it's imperative that the screen capture utility allows you to save captures in one or more industry standard file formats. Refer to Table 5-2 and Chapter 3 for more information on these file formats.

Ease of Use

Like any good graphics tool, a screen capture utility should be easy to use. Ease of use is important to consider since the last thing you want is a tool that is difficult to use and wastes your time rather than saves it. Therefore, make sure to look for a screen capture utility that supports such features as:

- Keyboard shortcuts
- Capture undo
- Automatic color palette correction
- Clipboard access
- Crop feature

Keyboard Shortcuts

Keyboard shortcuts are essential for capturing fast-action game screens or for capturing the screens of programs that don't rely on the mouse for input (i.e., DOS or joystick-driven games).

Make sure that the screen capture utility provides this option and allows you to redefine the shortcut keys for maximum flexibility.

Capture Undo

This feature allows you to undo the most recent screen capture. As the process of making screen captures is highly error prone, make sure this particular feature is available.

Automatic Color Palette Correction

This feature automatically accounts for and corrects any color palette "flashing" that might occur when many different programs are running at once in an 8-bit display mode.

This feature is needed because in display modes with 256 colors or less, Windows dynamically shifts the palette to whatever values are defined by the currently active window. Occasionally, this activity can introduce some unwanted color distortion into the captured screen, i.e., colors are jumbled.

Clipboard Access

This feature enables the program to directly copy the captured screen over to the Clipboard.

This makes it possible to access the screen capture in other Windows software without having to save it to disk first. It also makes it possible to import screen captures into software that may have no direct file import support.

Crop Feature

This means that the screen capture utility provides an option to *crop*, or trim, the captured image.

Cropping can be useful for cutting out extraneous portions from a capture before you save it to disk. Most screen capture utilities offer this feature, but some don't, so be aware of this.

NOTE: Be sure to look closely at Chapter 6 for specific reviews and recommendations of screen capture utilities that support most if not all of the features and tools described here.

Essential Image Viewer/Converter Features

To be useful, an image viewer/converter program needs to be able to read and write many different graphics formats and support many different display modes. Therefore, you should look for a program with features such as:

- Extensive graphic file format support
- Good interface
- Batch conversions
- Image catalogs
- Special operations

Extensive Graphic File Format Support

A good image viewer/converter program acts as a translator between many disparate graphic file formats. The best programs will support as many as 120 file formats. At the very least, it should support the file formats described in Table 5-2 and in Chapter 3. Make sure any software you evaluate does support these. If not, consider using another program as there are many from which to choose.

Good Interface

In order to be effective, an image viewer/conversion utility needs to have a good interface. This means that its commands and options should be visible and intuitive to use. Your time is precious and the last thing you want to do is waste it trying to figure out how to use a program.

Batch Conversions

One of the most important features of any image viewer/converter is its ability to convert large batches of files from one format to another at one time. For example, using the image viewer/converter program's batch conversion feature you can perform operations such as automatically converting all of your PCX format images to the Windows BMP RLE format in one fell swoop.

In any case, make sure that any image viewer/converter program you're looking at can do these kinds of file operations because sooner or later you'll have a need for something like this. When evaluating this feature, consider the program's speed. Programs that can process files faster are at an obvious advantage over slower programs, especially when you're dealing with dozens or even hundreds of files at once.

Image Catalogs

Many image viewer/converter programs are capable of generating mini-catalogs of your images. These catalogs usually contain small graphic thumbnails of your images, which can make it easier for you to manage and maintain your image collection. Therefore, look for a program that provides such a feature.

Special Operations

Image viewer/converter programs are also capable of performing a number of special and unusual operations on your graphics files including:

- Color reduction
- Color promotion
- Image scaling

Color Reduction

Color reduction is a process used to compress the size of image files by removing certain amounts of color information from an image. Typically, color reduction involves reducing 24-bit images down to 8-bit images or 8-bit images down to 64, 32, or 16 colors, etc. A number of image viewer/converter programs are capable of performing color reduction operations.

Whenever possible, look for color reduction that supports:

- **Palette remapping**—This is the ability to map a specific color palette to an image. This feature is important because different palettes can provide better color reduction results.
- **Dithering**—Dithering is a process that allows images to simulate the presence of colors that don't actually exist in an image. Clever dithering can make a color reduced image almost indistinguishable from the original source image. Therefore, make sure this option is provided.

Image viewer/converters vary wildly in their ability to perform color reduction. Some do exceptional jobs on most types of images while some don't. Because this class of programs does so many different things, it's important that you don't judge a program solely by how well it performs this particular function.

Most image viewer/converter programs can perform this operation on individual images as well as in batch.

Color Promotion

Color promotion is the opposite of color reduction. It enables you to promote, or convert an image from a lower color depth to a higher color depth. For example, using color promotion, you could bring a 16-color image up to 256 colors or an 8-bit image to 24-bit.

Most image viewer/converter programs can perform this operation on individual images as well as in batch.

Image Scaling

This function allows you to scale an image from one size to another. For example, you can reduce the size of an image from 640x480 down to 320x240 or scale it upward.

Most image viewer/converter programs can perform this operation on individual images as well as in batch.

Essential Palette Tool Features

A good palette tool will provide such features as:

- Color palette editing
- Color palette extraction from bitmaps
- Palette construction from input files
- Common file format support

Color Palette Editing

This tool allows you to create and edit color palettes in much the same way you would when using a painting program.

In addition to providing the usual functions to copy colors and create color gradients, this tool should allow you to load and save color palettes. There are two common palette file standards: Jasc PAL and Microsoft PAL. Both are well supported by painting programs. However, if you have a choice in the matter, you're better off using the Microsoft format as it's slightly more popular than the Jasc variety.

NOTE: All of the palette tools I've seen are for Windows only; therefore, this function only supports the RGB 0-255 color range.

Color Palette Extraction from Bitmaps

This tool allows you to generate color palettes from individual image files. For example, you can extract the color palette used by a screen capture from your favorite game and then edit it.

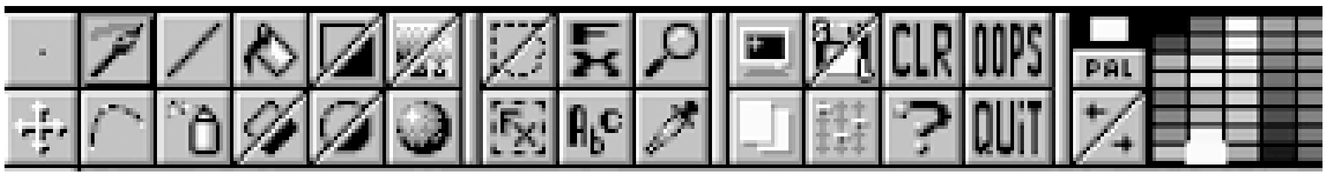
Most programs that offer this function allow you to extract color palettes from Windows BMP files. However, some will also support other file formats such as .PCX and .GIF, thus saving you the extra step of converting images to the BMP format.

Palette Construction from Input Files

This tool allows you to build color palettes by incorporating colors from one or more images. For example, you can create custom color palettes by using colors from three of your favorite game screens with this tool.

Common File Format Support

Make sure the palette tool can import files using one or more of the industry standard file formats. Refer to both Table 5-2 and Chapter 3 for more information on these file formats.



Chapter 6

Essential Graphics Tools

In this chapter, you'll learn about:

- **Recommended painting programs**
- **Recommended screen capture utilities**
- **Recommended image viewers/converters**
- **Recommended palette tools**
- **Other useful graphics utilities**

Criteria for My Recommendations

After spending countless hours scouring Internet software download sites, auction sites, and flea markets for graphics software that can handle the tricky business of creating arcade game graphics, I managed to find a number of tools that had all or most of the features outlined in Chapter 5.

In order to make the "cut," each program had to pass a rigorous evaluation process. Among the criteria examined were:

- Interface and ease of use
- Performance and stability
- Compatibility
- Unique or special features
- Availability and support
- Cost
- Gripes

Interface and Ease of Use

This looks at the overall quality of the program's interface. It considers such factors as the layout of the drawing area, the intuitiveness and placement of tools, and its consistency. These criteria are very important. A program with a poorly designed interface tends to be more difficult to use and can make you less productive than a program that has a well-designed interface.

Ease of use examines how easy the program is to use. Creating game artwork is challenging enough without forcing you to struggle with learning how to use yet another piece of software. Since everyone approaches arcade game graphics design with different levels of experience, it's crucial for a painting program to address the needs of both beginners and advanced users alike. This means it should have features that are friendly to new users without being overly obtrusive to experienced users.

Performance and Stability

Performance looks at how well a particular painting program runs on different systems. A program may provide every feature under the sun but if it doesn't run fast or smoothly on your computer, it really isn't worth using. For a program to be truly useful, it needs to be able to run well on both lower-end (i.e., 386, 486) and higher-end (i.e., Pentium, Pentium II, etc.) computer hardware at an acceptable level of performance.

Stability considers how prone the particular application is to errors and crashes. Some programs are bug-ridden and can crash your entire system while others are almost legendary in their ability to keep on working in a reliable fashion no matter what you throw at them. For obvious reasons, stable programs are preferable to unstable ones, not only because they're less likely to crash but also because they're less likely to take your artwork with them!

Compatibility

This criterion examines whether or not a program is compatible with standard, commonly available hardware and operating systems. A particular program might be loaded with features, have a great interface, and be fast, but if it doesn't run on your system, then all of its advantages are lost.

For testing compatibility, I used two different computer systems. At the low end, I used a generic PC compatible with a 133Mhz Pentium processor, 64 MB of RAM, and a 2 MB S3 Trio64 video card that ran Windows 95 OSR2. Meanwhile, at the high end, I used a 300Mhz Pentium II, Compaq PC with 192 MB of RAM, and an 8 MB Matrox Millenium video card that ran Windows NT 4.0 with SP 4.

NOTE: Since I ran my initial tests, Windows 2000 was released. Although I have managed to test some of the software mentioned here under this new operating system, I have not been able to test everything. As a result, I only mention compatibility with Windows 2000 on a case-by-case basis.

Unique or Special Features

This criterion looks at any extra or special features that a particular program might have. These features aren't essential to do graphics work but are certainly nice to have. However, I figured that I'd mention them anyway, especially since there may be a time when you find that you need to use one. The more the merrier, I always say.

Availability and Support

Availability looks at the program's availability in the marketplace and how easy it is to find and acquire a (legal) copy. Obviously, the more difficult it is to obtain a particular program, the less likely it is for you to be able to use it. I gave special preference to those programs that were easily found on the Internet since it offers us more immediacy when it comes to obtaining software.

Similarly, if a program isn't well supported or frequently updated, the chances are that the program bugs won't be fixed on a timely basis and its functionality won't be extended to meet your requirements down the road.

Cost

Cost considers the price of the software in question. I felt this was important to mention since many of us, including yours truly, are on tight budgets!

There's a wealth of powerful graphics software out there and contrary to popular perceptions, most of it is free or modestly priced. Therefore, unless you're desperate, have special needs, or like to waste money, there's really no reason to spend a lot of money for a good piece of graphics software.

In general, I only considered and evaluated programs that cost under $200 US. Most of them cost much less and quite a large number were free altogether. The issue of cost was, in fact, the only reason I didn't recommend Adobe's excellent *Photoshop* program in this book. As powerful and feature-rich as this program is, it just costs too much, especially if creating arcade games is a hobby rather than a livelihood.

NOTE: As this is a book with several months of production time, it's impossible to record the most accurate prices for the products reviewed in this chapter. As a result, you should always visit the appropriate vendor's Web site to get the latest pricing information.

Gripes

In addition to the other criteria mentioned here, I include my personal gripes with each program under a separate heading. This section also includes a list of features and/or program options that aren't supported but should be.

Finally, the programs themselves were categorized as follows:

- Recommended DOS painting programs
- Recommended Windows painting programs
- Recommended DOS screen capture utilities
- Recommended Windows screen capture utilities
- Recommended DOS image viewers/converters
- Recommended Windows image viewers/converters
- Recommended palette tools

NOTE: For clarification on what each of these different categories are, please consult Chapter 5.

Recommended DOS Painting Programs

- *Deluxe Paint IIe*
- *GrafX2*
- *Improcess*
- *NeoPaint*

Deluxe Paint IIe

Latest Version (at time of writing): 3.0

Native Platform: DOS but compatible with Windows 3.1, 95, 98, and NT 4.0

Type: Commercial

Publisher/Author: Electronic Arts

System Requirements: PC compatible, DOS 2.1 or better, 640 KB RAM, VGA or SVGA graphics card, and mouse

URL (at time of writing): N/A

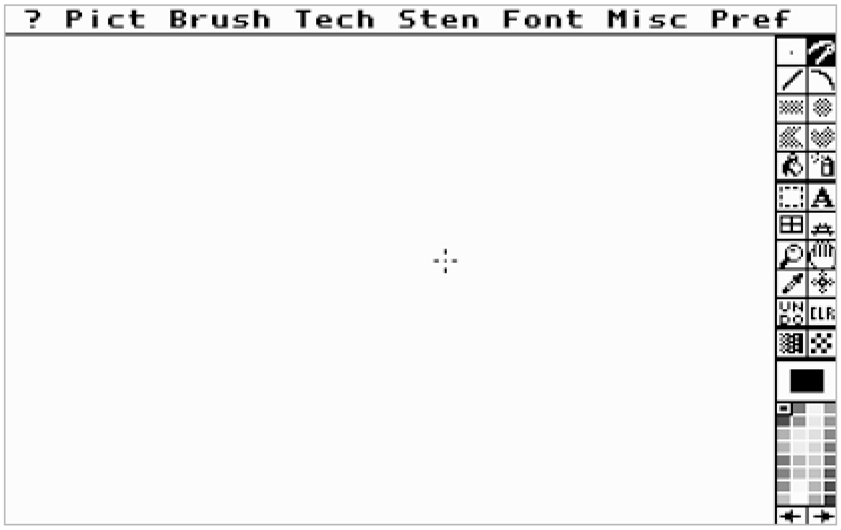


FIGURE 6-1: *Deluxe Paint IIe*

Deluxe Paint has long been a favorite in game development circles, making its first appearance on the Commodore Amiga in 1985. As its popularity increased, versions of it were eventually released on other popular platforms, including the Apple IIGS (1986), the PC (1988), and the Atari ST (1990).

There have been three PC versions of the program developed since its introduction: *Deluxe Paint II* (1988), *Deluxe Paint Animator* (1993), and *Deluxe Paint IIe* (1993). *Deluxe Paint II* was the original release and lacked many of the features that would eventually make *Deluxe Paint* so powerful. *Deluxe Paint Animator* and *Deluxe Paint IIe* both share the same core features but *Deluxe Paint Animator* also includes a powerful animation facility and only supports images with a 320x200 screen resolution. Finally, there is *Deluxe Paint IIe.* It is the most capable of the three and the one I decided to review here.

TABLE 6-1: *Deluxe Paint IIe* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	Its drawing screen is refreshingly uncluttered and lets you get to work right away. All of the program's tools and functions are easily and readily accessible.
Performance and stability	Excellent	Works very well on older systems, especially slower 386, 486, and Pentium class machines. Very stable.
Compatibility	Very good	Appears to be fully compatible with modern 32-bit operating systems like Windows 95, 98, and NT 4.0. It also is one of the few graphics programs that runs reliably under Windows 3.1.
Unique or special features	Very good	■ Has a special Perspective tool that lets you manipulate image blocks along the X-, Y-, and Z-axes in order to create 3D-like backgrounds. ■ Supports all program tools while zoomed. ■ Includes a Symmetry tool that allows you to produce symmetrical shapes and patterns by mirroring and duplicating pixels as you draw them. ■ Automatically creates backups of your images. This is useful in case you make a fatal mistake on your current masterpiece.
Cost	Fair	Expect to pay about $30-100 for used copies depending on source.
Availability and support	Poor	*Deluxe Paint* is no longer marketed or supported by its publisher, Electronic Arts. However, it can still be obtained from software dealers who specialize in discontinued or second-hand software. In addition, it can occasionally be found on various Internet auction sites.
Gripes	Fair	■ Provides only sketchy native support for common SVGA display modes. This means that some users won't be able to reliably access display modes with screen resolutions above 320x200 unless you use a third-party VESA driver.

Criteria	*Rating*	*Comments*
		■ Only provides users with two drawing screens. This limits your ability to work on multiple images at once and copy elements between them. ■ Only supports the PCX and LBM file formats. ■ Uses a proprietary text font format for its Text tool. As a result, it's impossible to add new fonts to the program and the included fonts lack significant variation in style compared to what's available with TrueType fonts.

TABLE 6-2: *Deluxe Paint* Feature Summary

Drawing Tools and Effects	*Supported*	*Comments*
The Pencil tool		Not implemented. However, its Brush tool offers something similar.
The Brush tool	✓	Supports multiple brush widths.
The Airbrush tool	✓	Allows you to control the size and flow of the spray.
The Line tool	✓	Can also produce connected line segments and control the width of the line.
The Curve tool	✓	Can produce two types of curves: simple and one with multiple endpoints.
The Rectangle tool	✓	Can produce both filled and unfilled rectangles as well as squares. Supports gradient fills for this tool.
The Ellipse tool	✓	Can produce filled and unfilled ellipses as well as rotated ellipses. Supports gradient fills for this tool.
The Polygon tool	✓	Can produce both filled and unfilled polygon shapes. Supports gradient fills for this tool.
The Fill tool	✓	Can fill in areas with solid colors, patterns, and gradient fills. Allows you to fill in objects using straight, shaped, ridged, radial, and contoured gradients.
The Selection tool	✓	Can perform cut, copy, and paste operations. In addition, it also supports block resizing, rotation, bending, shearing, halving, doubling, flipping, and converting objects into single colors, as well as the loading and saving of blocks.
The Lasso tool	✓	Offers the same features as the Selection tool. The Lasso tool always operates on blocks transparently.
The Zoom tool	✓	Can magnify screen sections up to 2, 3, 4, 6, and 8 times their original size. Allows you to use all available tools while in magnification mode.
The Navigator tool	✓	Allows you to view the entire screen and scroll around the entire image.

Drawing Tools and Effects	*Supported*	*Comments*
The Eye Dropper tool	✓	Includes the standard functionality for this tool.
The Palette Selector	✓	Provides all major features including the ability to define colors, swap color values, copy color values, and define color gradients. It doesn't allow you to load or save color palettes, however.
Brighten		Not implemented.
Darken		Not implemented.
Smooth	✓	Includes the standard functionality for this tool.
Smear	✓	Includes the standard functionality for this tool.
Invert		Not implemented.
The Translucency tool	✓	Allows you to specify the level of translucency.
The Stencil tool	✓	Includes a simple but powerful Stencil function that gives you full control over individual colors and the ability to load and save stencils for future use.
The Anti-alias tool	✓	Works with all drawing tools. Uses a single anti-aliasing algorithm but usually produces very effective results.
The Colorize tool	✓	Works exceptionally well, particularly on color gradients of the same intensity.
The Shade tool	✓	Includes the standard functionality for this tool.
The Grid tool	✓	All tools can snap to the grid, and grid spacing is definable both interactively with the mouse and through dialog box values.
The Eraser tool		Not implemented.
The Clear tool	✓	Includes the standard functionality for this tool. Can be undone with the Undo tool.
The Undo tool	✓	Provides an "undoable" undo function. However, it doesn't support an undo history so you can't undo successive operations.
The Text tool	✓	Includes the standard functionality for this tool. Utilizes a proprietary font format, which makes adding fonts to the program impossible. Supports bold, italic, and underline type in these point sizes: 8, 12, 18, 24, 36, 48, 56, 72, and 96. Doesn't support leading, kerning, or tracking control.
Industry standard file formats	✓	Loads and saves both PCX (8-bit only) and IFF/LBM (8-bit only). Comes with a separate utility to do other file format conversions. All images are limited to 256 (8-bit) colors.

Drawing Tools and Effects	*Supported*	*Comments*
Multiple display mode support	✓	Included video drivers support most common VGA and SVGA graphics cards in display modes of 320x200 to 1024x768 in 256 colors. However, many of these built-in drivers are obsolete and you'll probably need a third-party VESA driver to get most of them to work.
Multiple work screen support	✓	Only supports two work screens. This is enough for some users but too limiting for others.
Keyboard shortcuts	✓	Offers extensive support for keyboard shortcuts. Virtually every program feature has a keyboard shortcut associated with it.
Coordinate tracking	✓	Includes the standard functionality for this tool.

GrafX2

Latest Version (at time of writing): 2.0 Beta 96.5%

Native Platform: DOS, but compatible with Windows 3.1, 95, 98, NT 4.0, and 2000

Type: Freeware

Publisher/Author: Sunset Design Software

System Requirements: PC compatible, DOS 5.0 or better, 5 MB of RAM, VGA or SVGA graphics card, and mouse

URL (at time of writing): http://www-msi.ensil.unilim.fr/~maritaud/sun-set/grafx2.html

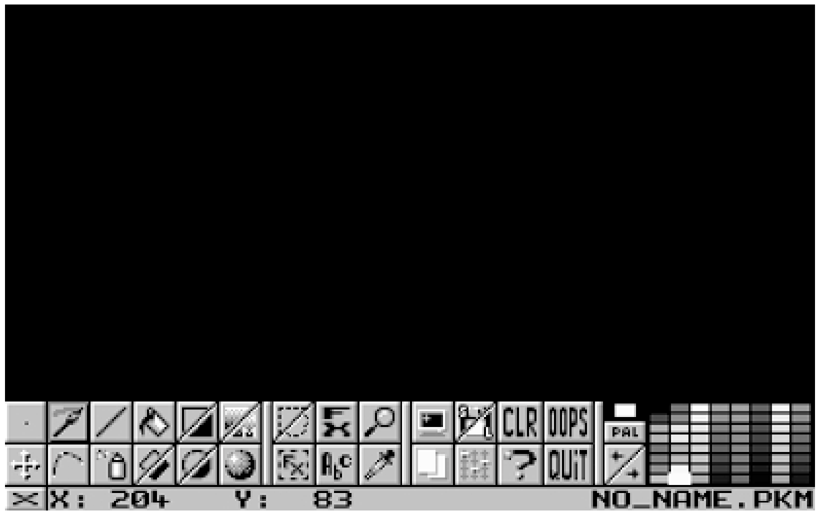


FIGURE 6-2: *GrafX2*

Two members of a French demo-coding group developed *GrafX2* back in 1996. Their unique perspective as both talented programmers and artists enabled them to produce one of the most exciting and original painting programs to appear on the PC platform in many years. While *GrafX2* is new to me, it apparently has been a favorite among European demo group artists for some time.

If it's ever completed and developed to its potential, it stands to surpass even *Deluxe Paint IIe* as the leader in PC-based painting software.

TABLE 6-3: *GrafX2* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	Its drawing screen is clear and uncluttered so you'll be able to start drawing immediately. All of *GrafX2's* tools are easy to find and are well positioned within the tool bar. Makes good use of keyboard shortcuts.
Performance and stability	Excellent	*GrafX2* accesses the computer's graphics hardware directly so it runs at exceptional speed, even on slower systems, without requiring lots of memory. However, it experiences some stability issues that will lead it to crash in certain situations.
Compatibility	Very good	Works very well with Windows 95, 98, NT 4.0, and 2000, making it the perfect complement to your Windows game development efforts. Unfortunately, this great program isn't compatible with systems running Windows 3.1.
Unique or special features	Good	■ Provides a tiling function that lets you easily create tiled graphics. This feature is useful for testing background images, etc. ■ Can reduce colors in images, i.e., reduce a 128-color image to 64 colors with good results. ■ Supports all program tools while zoomed. ■ Can be optionally configured to create backups of your images. This is useful should you make a fatal mistake when working on your current masterpiece.
Cost	Excellent	Free.
Availability and support	Good	Free for all to download although it's not that easy to find. The program is also still under development, but so far, it has been well supported by its authors.

Criteria	*Rating*	*Comments*
Gripes	Fair	■ Doesn't allow you to create rectangles with filled color gradients. ■ Doesn't have a Text tool. Therefore, there's no easy way to add text to an image with this program. ■ Doesn't yet allow you to apply special effects to the whole picture at once and certain block functions such as free-rotate and block distort aren't yet implemented. ■ Doesn't provide an Anti-alias or a true Colorize function.

TABLE 6-4: *GrafX2* Feature Summary

Drawing Tools and Effects	*Supported*	*Comments*
The Pencil tool		Not implemented. However, its Brush tool offers something similar.
The Brush tool	✓	Also supports multiple brush widths.
The Airbrush tool	✓	Allows you to control the size and flow of the spray.
The Line tool	✓	Can produce both connected line segments and continuous line segments.
The Curve tool	✓	Can produce two types of curves: simple and one with multiple endpoints.
The Rectangle tool	✓	Can produce both filled and unfilled rectangles. You can't draw squares with it. Doesn't allow you to create rectangles with gradient fills.
The Ellipse tool	✓	Only allows you to draw circles but lets you create circles with gradient fills.
The Polygon tool	✓	Can produce both filled and unfilled polygon shapes. Doesn't support gradient fills.
The Fill tool	✓	Can fill in areas with solid colors, patterns, and gradient fills. Only allows you to use radial gradient fills but allows you to define the angle of the fill.
The Selection tool	✓	Can perform cut, copy, and paste operations. In addition, this program also supports block resizing, rotation (limited to 90- and 180-degree increments), and flipping.
The Lasso tool	✓	Provides the same basic features as the Selection tool. The Lasso tool always operates on blocks transparently.
The Zoom tool	✓	Can magnify screen sections up 2, 3, 4, 6, 8, 12, 14, 16, 18, and 20 times their original size. Also allows you to use all tools while in magnification mode.

Drawing Tools and Effects	*Supported*	*Comments*
The Navigator tool	✓	Allows you to view the entire screen and scroll around the entire image.
The Eye Dropper tool	✓	Includes the standard functionality for this tool.
The Palette selector	✓	Provides all major features including the ability to define colors, swap color values, copy color values, and define color gradients. In addition, it lets you invert color values (reverse their order), swap entire ranges of color, convert the palette to grayscale, undo any palette changes, and return the current palette to its default state. It also lets you count the number of colors used in an image and perform color reduction. Supports the Microsoft PAL format.
Brighten		Currently not implemented.
Darken		Currently not implemented.
Smooth	✓	Includes the standard functionality for this tool and provides three different algorithms for the smoothing process.
Smear	✓	Includes the standard functionality for this tool.
Invert		Currently not implemented.
The Translucency tool	✓	Allows you to specify the level of translucency and choose from either additive or subtractive translucency.
The Stencil tool	✓	Includes a simple but powerful Stencil function that gives you full control over individual colors and the ability to load and save stencils for future use.
The Anti-alias tool		Currently not implemented.
The Colorize tool	✓	Not the same as in *Deluxe Paint*. Doesn't preserve the original object's color intensity.
The Shade tool	✓	Includes the standard functionality for this tool.
The Grid tool	✓	All tools can snap to the grid, and grid spacing is definable both interactively with the mouse and through dialog box values.
The Eraser tool		Not implemented.
The Clear tool	✓	Includes the standard functionality for this tool. Can be undone with the Undo tool.
The Undo tool	✓	Provides an "undoable" undo function. However, it doesn't support an undo history so you can't undo successive operations.
The Text tool		Currently not implemented.

Drawing Tools and Effects	*Supported*	*Comments*
Industry standard file formats	✓	Loads and saves PCX, BMP, GIF, and IFF/LBM images. All images are restricted to 256 (8-bit) colors. The program also allows you to save color palettes in Microsoft's PAL format.
Multiple display mode support	✓	Provides extensive display mode support. The program is capable of generating and supporting up to 60 different VGA and SVGA display modes, including many non-standard Mode X display modes that are useful to game programmers.
Multiple work screen support	✓	Like *Deluxe Paint*, it supports two work screens with the ability to copy color palettes between them.
Keyboard shortcuts	✓	Offers extensive support for keyboard shortcuts. Virtually every program feature has a keyboard shortcut associated with it. The program comes with a special configuration utility that allows you to redefine the keyboard shortcuts.
Coordinate tracking	✓	Includes the standard functionality for this tool.

NOTE: You can find *GrafX2* on the CD-ROM that accompanies this book. Please refer to Appendix B for more information.

Improces

Latest Version (at time of writing): 4.2

Native Platform: DOS, but compatible with Windows 3.1, 95, 98, and NT 4.0

Type: Freeware

Publisher/Author: John Wagner

System Requirements: PC compatible, DOS 3.0 or better, 640KB RAM, VGA or SVGA graphics card, and mouse

URL (at time of writing): http://homepages.together.net/~jwag/freesoftware.html

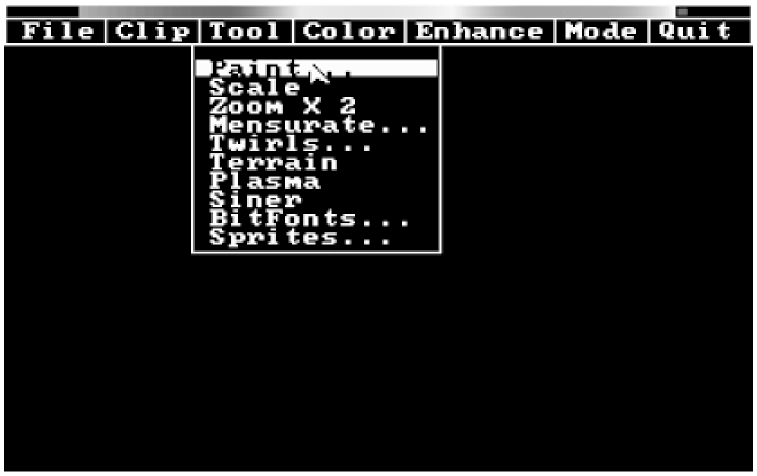


FIGURE 6-3: *Improces*

Improces is a program that you'll either love or hate. It's been around for years and has so many features that it's often hard to classify it as strictly a painting program.

Programmer John Wagner created *Improces* in 1991 in order to fully exploit the power of the PC's impressive VGA graphics capabilities. In many ways, he succeeded. As a graphics package, *Improces* straddles many different areas within the graphics field; it's part painting program, part image editor, and part image processing program.

Unfortunately, while these multiple personalities make *Improces* a very powerful program, they also contribute to its well-deserved reputation for being cumbersome and difficult to use.

TABLE 6-5: *Improces* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Poor	Not very easy to use overall. Many of the program's features aren't very intuitive or easy to use.
Performance and stability	Excellent	Runs smoothly on slow PC systems (i.e., 286 and 386 systems). Users with faster systems will find the program's performance proportionally faster. Appeared to be very stable on all systems tested.
Compatibility	Very good	Works quite well under Windows 3.1, 95, 98, and NT 4.0. It also appears to be compatible with most VGA and SVGA cards, although your actual experience may vary depending on your particular hardware setup.

Criteria	*Rating*	*Comments*
Unique or special features	Very good	■ Includes a simple but effective sprite animation facility where you can test the animations you create. It supports variable playback speeds in two different directions and allows you to preview animations of up to 12 frames in length. ■ Provides a number of image processing tools, giving it much of the same capability of programs costing much more. ■ One of the few programs that can generate plasmas, or fractal-like color patterns, which are useful for game title and background screens. ■ Allows you to create graphics in several common Mode X display modes. ■ Can use both ZSoft and Borland Stroked fonts with its Text tool.
Cost	Excellent	Free.
Availability and support	Fair	The program is relatively easy to find online; however, the author no longer updates or supports the program.
Gripes	Poor	■ Doesn't offer an undoable Undo function. What's more, its standard Undo function is very limited in terms of what painting operations it will reverse. ■ Has a poorly designed interface. ■ Uses a custom video driver that doesn't work with some graphics cards in screen resolutions above 320x400. ■ Its implementation and support of multiple screens is inconvenient to work with. ■ The Text tool is rather limited in function. Compared to other programs mentioned here, it's difficult to use and edit text. ■ Doesn't provide an Anti-alias or a Colorize function. ■ Doesn't work with all tools while zoomed.

TABLE 6-6: *Improces* Feature Summary

Drawing Tools and Effects	*Supported*	*Comments*
The Pencil tool	✓	Draws lines in solid colors.
The Brush tool	✓	Supports multiple brush widths.
The Airbrush tool	✓	Allows you to control the size of the spray.
The Line tool	✓	Allows you to create connected line segments and control the width of the line.

Drawing Tools and Effects	*Supported*	*Comments*
The Curve tool	✓	Supports two types of curves: simple and one with multiple endpoints.
The Rectangle tool	✓	Lets you draw both filled and unfilled rectangles as well as squares. Doesn't support gradient fills.
The Elipse tool	✓	Lets you draw filled and unfilled ellipses as well as rotated ellipses. Doesn't support gradient fills.
The Polygon tool	✓	Allows you to draw both filled and unfilled polygon shapes. Doesn't support gradient fills.
The Fill tool	✓	Lets you fill areas with solid colors, patterns, and gradient fills. Also allows you to fill in objects using straight, ridged, and radial gradients. Produces great results but is difficult to use.
The Selection tool		Has a limited copy and paste function and doesn't quite work as you would expect it to.
The Lasso tool		Not implemented.
The Zoom tool	✓	Only supports 4x magnification. Doesn't allow you to use other tools or functions except the ability to change the current drawing color.
The Navigator tool		Not implemented.
The Eye Dropper tool		Not implemented.
The Palette selector	✓	Only allows you to change color values and color gradients. Supports color palette reduction.
Brighten	✓	Includes the standard functionality for this tool.
Darken	✓	Includes the standard functionality for this tool.
Smooth	✓	Known as Average and Median. Can work on either block selections or the entire image.
Smear		Not implemented.
Invert	✓	Includes the standard functionality for this tool.
The Translucency tool		Not implemented.
The Stencil tool		Not implemented.
The Anti-alias tool		Not implemented.
The Colorize tool		Not implemented.
The Shade tool		Not implemented.
The Grid tool	✓	Doesn't support grid snapping but can draw fixed grids of 128x128 pixels in size.
The Eraser tool		Not implemented.
The Clear tool	✓	Includes the standard functionality for this tool.

Drawing Tools and Effects	*Supported*	*Comments*
The Undo tool	✓	Very limited. Only works after certain operations and doesn't support an undoable Undo.
The Text tool	✓	Supports both ZSoft bitmapped fonts and Borland Stroked fonts. Only provides limited text editing capabilities. Doesn't support leading, kerning, or tracking control.
Industry standard file formats	✓	Can load PCX, GIF 87a, and TGA files. Can save files in PCX, GIF 87a, and TGA formats as well.
Multiple display mode support	✓	Supports most common display modes and Mode X screen resolutions at a maximum of 256 colors.
Multiple screen support	✓	Supports multiple work screens but implements them in a weird way. As a result, using multiple screens isn't as fast or convenient as with other packages described here.
Keyboard shortcuts	✓	Supports only limited keyboard shortcuts.
Coordinate tracking		Not implemented.

NOTE: You can find *Improces* on the CD-ROM that accompanies this book. Please refer to Appendix B for more information.

NeoPaint

Latest Version (at time of writing): 3.2d

Native Platform: DOS, but compatible with Windows 3.1, 95, 98, and NT 4.0

Type: Shareware

Publisher/Author: NeoSoft, Inc.

System Requirements: PC compatible, DOS 3.1 or better, 640 KB RAM, VGA or SVGA graphics card, and mouse

URL (at time of writing): http://www.neosoftware.com/np.html

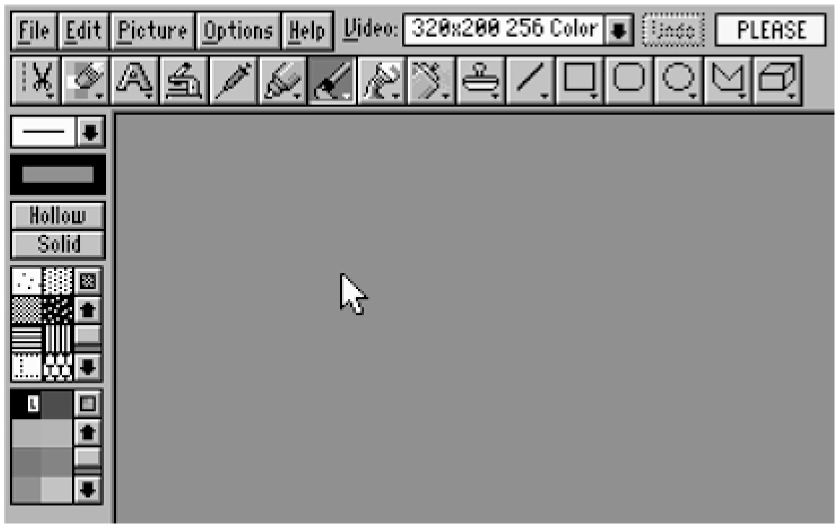


FIGURE 6-4: *NeoPaint*

NeoPaint is a general-purpose painting program that also happens to be a reasonably decent tool for creating arcade game graphics.

NeoPaint first appeared in 1994 and has since undergone several revisions and enhancements. Over the years it's garnered a rather large following among game developers due to its wide availability, impressive features, low cost, and sleek Windows-like interface.

TABLE 6-7: *NeoPaint* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	The program rises above the rest of crowd in the sophistication of its interface. Its programmers went to the trouble of developing an entire, mouse-driven windowing system to ensure that *NeoPaint* would be easy to use for users of all levels.
Performance and stability	Good	*NeoPaint*'s custom windowing system eats up a surprising amount of computer resources. This makes it somewhat slower in graphics operations when compared to the other programs reviewed here, especially when running on slower machines. Despite this, *NeoPaint* has proven itself to be a very stable and reliable program.
Compatibility	Excellent	*NeoPaint* is one of the most stable DOS graphic programs I've ever used. It's never crashed, and it seems to run great under all versions of DOS and Windows that I tested.

Criteria	*Rating*	*Comments*
Unique or special features	Excellent	■ Does a great job of managing multiple work screens. You can easily create and manage dozens of screens simultaneously without problems. ■ Unique among DOS-based graphics packages in that it supports display modes from 320x200 to 1024x768 and color depths of 4, 8, 16, and 24 bits, provided you have compatible display hardware. ■ Adding text with *NeoPaint* is very easy thanks to its Windows-like font selection dialog and sophisticated text editor. It even allows you to import small text files! ■ Supports a wide array of popular graphics formats, including Windows BMP. ■ Provides a large number of image processing functions and special effects. ■ Provides good support and compatibility with most VGA and SVGA cards. ■ Includes (as an external program) a DOS screen capture utility.
Cost	Excellent	$45 (US)
Availability and support	Good	Easily found online and well supported. However, it probably won't be upgraded given the recent release of the Windows version of the program.
Gripes	Fair	■ Doesn't provide an undoable Undo function. ■ Many of its various filters and special effects are slow, particularly on older machines. ■ Doesn't allow you to use all of its drawing tools when using the Zoom tool. ■ Offers a limited gradient fill capability. All of its gradient fill angles are predefined. ■ Handles image blocks in a cumbersome fashion. It takes several steps to perform the same action that other programs can perform in one. ■ Selecting palette colors is a somewhat tedious process. ■ Doesn't provide an Anti-alias or a Colorize function.

TABLE 6-8: *NeoPaint* Feature Summary

Drawing Tools and Effects	*Supported*	*Comments*
The Pencil tool	✓	Includes the standard functionality for this tool.
The Brush tool	✓	Provides several brush sizes, shapes, and effects, including charcoal, magic marker, and ink. Also supports multiple brush widths and brush cloning, a feature typically found only in image editors.
The Airbrush tool	✓	Allows you to control the size of the spray.
The Line tool	✓	Can produce connected line segments and control the width of the line.
The Curve tool	✓	Supports two types of curves: simple and one with multiple endpoints.
The Rectangle tool	✓	Can produce both filled and unfilled rectangles as well as squares.
The Ellipse tool	✓	Can produce filled and unfilled ellipses as well as rotated ellipses.
The Polygon tool	✓	Can produce both filled and unfilled polygon shapes as well as gradient fills. Also lets you create basic 3D shapes.
The Fill tool	✓	Can fill in areas with solid colors, patterns, and gradient fills. Also allows you to fill in objects using straight, shaped, ridged, and radial gradients. However, these gradients use predefined fill directions and are much more limited than those featured in *Deluxe Paint* and *GrafX2*.
The Selection tool	✓	Can perform cut, copy, and paste operations. In addition, it also supports block resizing, rotation, bending, shearing, halving, doubling, flipping, and converting objects into single colors, as well as loading and saving blocks.
The Lasso tool	✓	Same features as the Selection tool. The Lasso tool always operates on blocks transparently. Offers several variations of this tool for maximum flexibility.
The Zoom tool	✓	Can magnify screen sections from 2 to 100 times their original size. Unfortunately, it doesn't allow you to use all tools while zoomed.
The Navigator tool	✓	Allows you to view the entire screen and scroll around the entire image.
The Eye Dropper tool	✓	Includes the standard functionality for this tool.

Drawing Tools and Effects	*Supported*	*Comments*
The Palette selector	✓	Includes the standard functionality for this tool. Also supports copying of colors and the loading and saving of palettes but not in the Microsoft .PAL format.
Brighten	✓	Allows you to brighten regions as well as the entire image.
Darken	✓	Allows you to darken regions as well as the entire image.
Smooth	✓	Allows you to smooth regions as well as the entire image.
Smear	✓	Includes the standard functionality for this tool.
Invert		Not implemented.
The Translucency tool		Not implemented.
The Stencil tool		Not implemented.
The Anti-alias tool		Not implemented.
The Colorize tool		Not implemented.
The Shade tool		Not implemented.
The Grid tool	✓	Includes the standard functionality for this tool.
The Eraser tool	✓	Includes the standard functionality for this tool.
The Clear tool	✓	Includes the standard functionality for this tool.
The Undo tool	✓	Includes the standard functionality for this tool. Doesn't support undoable Undos, however.
The Text tool	✓	Provides sophisticated text handling. Compatible with GEM bitmapped fonts. Allows you to import ASCII text files. Doesn't support leading, kerning, or tracking control, however.
Industry standard file formats	✓	Can load PCX, TIFF, or BMP files. Can save PCX, TIFF, and BMP files.
Multiple display mode support	✓	Supports display modes with 4-, 8-, 16-, or 24-bit color depth, provided your video card has the proper drivers.
Multiple screen support	✓	Additional screens are limited only by available memory. Provides an elegant system of managing multiple screens.
Keyboard shortcuts	✓	Makes extensive use of keyboard shortcuts. However, many are not intuitive.
Coordinate tracking		Not implemented.

NOTE: You can find a trial version of *NeoPaint* on the CD-ROM included in this book. Please refer to Appendix B for more information.

Other Useful DOS Painting Programs

There were a number of DOS-based painting programs that met most of my review criteria but ultimately weren't recommended for various reasons. Nevertheless, they are mentioned here and include such programs as:

- *DN Paint*—A free painting program with some extremely powerful tools and features. It looks like a promising addition to your creative toolbox if you can get it to run on your system!
- *VGA Paint 386*—A free *Deluxe Paint* clone that shares much of the original's powerful functionality.

NOTE: Some or all of these programs are included on the book's accompanying CD-ROM. Refer to Appendix B for additional details.

Recommended Windows Painting Programs

- *NeoPaint for Windows*
- *Paint Shop Pro*
- *Pro Motion*

NeoPaint for Windows

Latest Version (at time of writing): 4b

Native Platform: Windows 95, 98, NT 4.0, and 2000

Type: Shareware

Publisher/Author: NeoSoft, Inc.

System Requirements: PC compatible, Windows 95, 98, or NT 4.0, and an SVGA graphics card

URL (at time of writing): http://www.neosoftware.com/npw.html

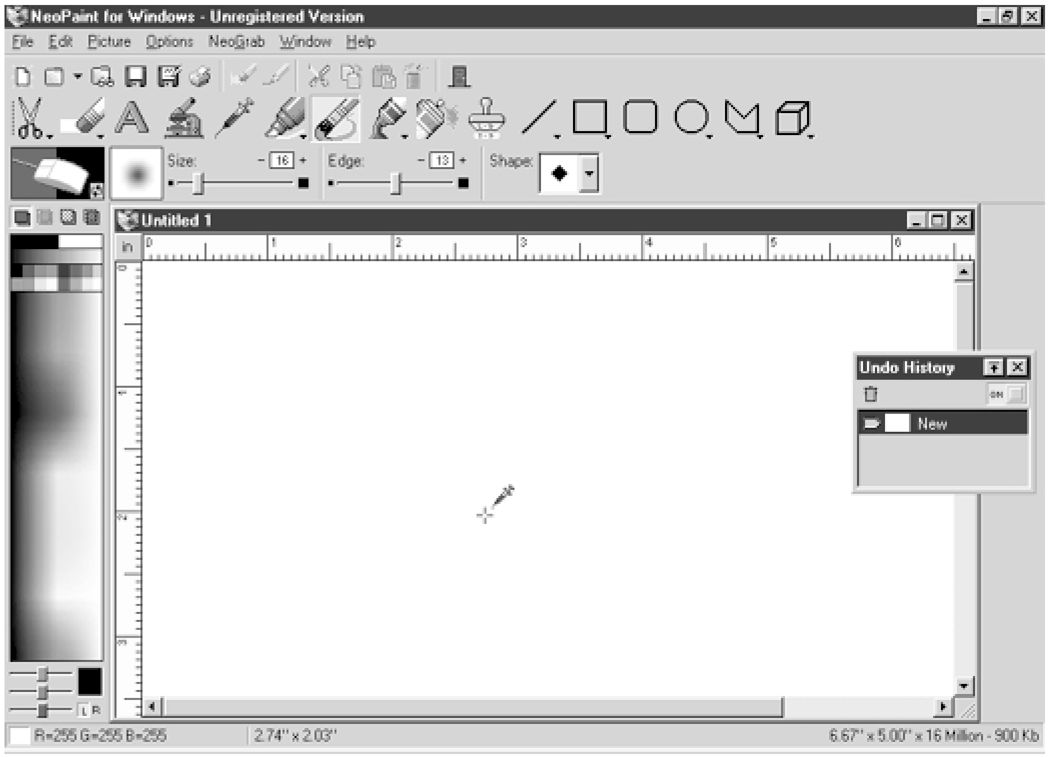

NeoPaint for Windows - Unregistered Version
File Edit Picture Options NeoGrab Window Help
Size: 16
Edge: 13
Shape:
Untitled 1
Undo History
New
R=255 G=255 B=255
2.74" x 2.03"
6.67" x 5.00" x 16 Million - 900 Kb

FIGURE 6-5: *NeoPaint for Windows*

At first glance, *NeoPaint for Windows* just looks like a 32-bit Windows conversion of *NeoPaint for DOS*. But despite sharing many of the original's features and interface elements, the two are really different programs.

NeoPaint for Windows expands on the original DOS version's feature set and improves on it in a number of areas. Among its improvements are a fully Windows compliant interface, support for more graphic file formats, a new and more flexible Zoom tool, better video display mode support, and a slew of new special effects.

In short, *NeoPaint for Windows* is a completely new program that addresses many of the original's shortcomings. If you're interested in a low-cost and feature-rich program for creating game graphics, you should strongly consider using this program.

TABLE 6-9: *NeoPaint for Windows* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	Interface is a combination of Windows standards and the earlier *NeoPaint for DOS* product. Some users will recognize the similarities and immediately feel at home, while other users will be distracted by the many options it offers. Despite this, the program features are clearly labeled and all in all, I found it very easy to use.
Performance and stability	Very good	Runs well on slower systems. However, certain tools, most notably large brushes or some special effects, tend to be on the sluggish side. Seems very stable on all systems tested.
Compatibility	Excellent	Compatible with all versions of Windows from 95 through Windows 2000.
Unique or special features	Excellent	■ Supports a wide array of popular graphics formats, including Macintosh PICT and Photoshop PSD. ■ Allows you to take screen captures from inside the program. ■ Supports display modes of various color depths and screen resolutions and can promote or reduce colors between different display modes. ■ Supports an undo history that allows certain actions to be easily repeated. ■ Supports a large number of special effects, all of which can be previewed before applying them to your images. ■ Supports all program tools while zoomed. ■ Can import text from external text files. ■ Provides a simple but informative help facility.
Cost	Excellent	$59.95 (US) or $34.95 (US) as an upgrade from the original DOS version.
Availability and support	Excellent	Easily found online and relatively well supported.
Gripes	Very good	■ Offers a limited gradient fill capability. All of its gradient fill angles are predefined. ■ Doesn't provide an Anti-alias or a Colorize function. ■ Its interface occupies a large amount of usable screen area.

TABLE 6-10: *NeoPaint for Windows* Feature Summary

Drawing Tools and Effects	*Supported*	*Comments*
The Pencil tool	✓	Includes the standard functionality for this tool.
The Brush tool	✓	Provides several brush sizes, shapes, and effects, including charcoal, magic marker, and ink. Also supports multiple brush widths and brush cloning, a feature typically found only in image editors.
The Airbrush tool	✓	Allows you to control the size and rate of the spray.
The Line tool	✓	Can produce connected line segments and control the width of the line.
The Curve tool	✓	Supports two types of curves: simple and one with multiple endpoints.
The Rectangle tool	✓	Can produce both filled and unfilled rectangles as well as squares.
The Ellipse tool	✓	Can produce filled and unfilled ellipses as well as rotated ellipses.
The Polygon tool	✓	Can produce both filled and unfilled polygon shapes as well as gradient fills. Also lets you create basic 3D shapes.
The Fill tool	✓	Lets you fill in areas with solid colors, patterns, and gradient fills. Also allows you to fill in objects using straight, shaped, ridged, radial, and contoured gradients but doesn't allow you to adjust the fill angle.
The Selection tool	✓	Includes the standard functionality for this tool and supports a number of image block manipulation functions.
The Lasso tool	✓	Includes the standard functionality for this tool and supports a number of image block manipulation functions.
The Zoom tool	✓	Lets you magnify screen sections from 2 to 51 times their original size. However, it doesn't allow you to use all tools while zoomed.
The Navigator tool	✓	Allows you to view the entire screen at once but uses a crude form of this tool.
The Eye Dropper tool	✓	Includes the standard functionality for this tool.

Drawing Tools and Effects	*Supported*	*Comments*
The Palette selector	✓	Provides all major features including the ability to define colors, swap color values, copy color values, and define color gradients. In addition, it lets you undo any palette changes and return the current palette to its default state. It also lets you count the number of colors used in an image and perform color reduction. Also supports the loading and saving of palettes but not in the Microsoft .PAL format.
Brighten	✓	Allows you to brighten regions as well as the entire image.
Darken	✓	Allows you to darken regions as well as the entire image.
Smooth	✓	Allows you to smooth regions as well as the entire image.
Smear	✓	Includes the standard functionality for this tool.
Invert		Not implemented.
The Translucency tool		Not implemented.
The Stencil tool	✓	Doesn't support color-based stencils but does support screen masks in higher-color display modes.
The Anti-alias tool		Not implemented.
The Colorize tool		Not implemented.
The Shade tool		Not implemented.
The Grid tool	✓	Includes the standard functionality for this tool.
The Eraser tool	✓	Includes the standard functionality for this tool.
The Clear tool	✓	Includes the standard functionality for this tool.
The Undo tool	✓	Doesn't support an undoable Undo but does support an undo history, which can simulate some of this functionality.
The Text tool	✓	Includes the standard functionality for this tool. Allows you to anti-alias text and treat text as a block selection for further manipulation. Supports Windows TrueType fonts and can import text from the Clipboard and external text files. Doesn't support leading, kerning, or tracking control.
Industry standard file formats	✓	Can load BMP, PNG, JPEG, GIF 87a/89a, PSD, PCX, TIFF, TGA, and Macintosh PICT. Can save BMP, PNG, GIF 87a/89a, PSD, PCX, TIFF, JPEG, TGA, and Macintosh PICT.

Drawing Tools and Effects	*Supported*	*Comments*
Multiple display mode support	✓	Supports all display modes supported by Windows and your video hardware.
Multiple screen support	✓	Available work screens are limited only by available memory.
Keyboard shortcuts	✓	Makes extensive use of keyboard shortcuts. Uses a combination of standard Windows keyboard shortcuts and *NeoPaint for DOS* keyboard shortcuts.
Coordinate tracking	✓	Includes the standard functionality for this tool and allows you to specify the coordinate metric between pixels and inches or centimeters.

NOTE: You can find a fully functional trial version of *NeoPaint for Windows* on the CD-ROM included in this book. Please refer to Appendix B for more information.

Paint Shop Pro

Latest Version (at time of writing): 6.02

Native Platform: Windows 95, 98, NT 4.0, and 2000

Type: Shareware

Publisher/Author: Jasc, Inc.

System Requirements: PC compatible, Windows 95, 98, NT 4.0, or 2000, mouse, and an SVGA graphics card

URL (at time of writing): http://www.jasc.com/products.html

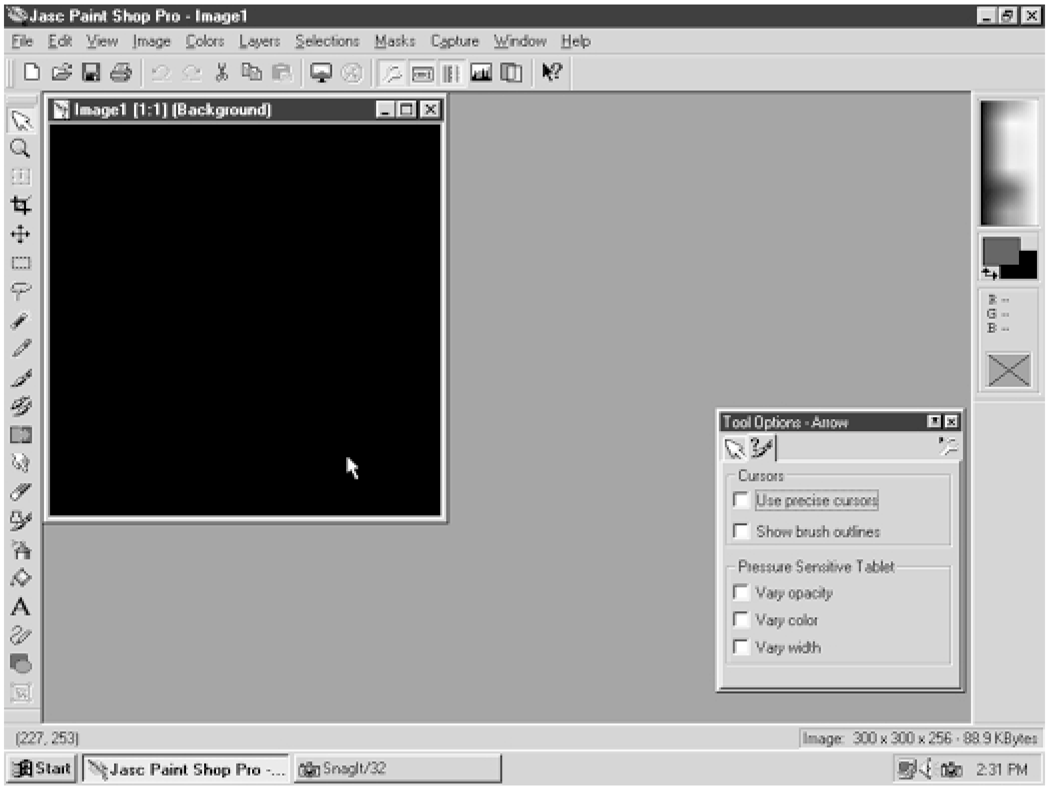

Jasc Paint Shop Pro - Image1
File Edit View Image Colors Layers Selections Masks Capture Window Help
Image1 [1:1] (Background)
Tool Options - Arrow
Cursors
Use precise cursors
Show brush outlines
Pressure Sensitive Tablet
Vary opacity
Vary color
Vary width
(227, 253)
Image: 300 x 300 x 256 - 88.9 KBytes
Start
Jasc Paint Shop Pro -...
SnagIt/32
2:31 PM

FIGURE 6-6: *Paint Shop Pro*

Paint Shop Pro has been around since the early 1990s and each release of the program has brought new features and capabilities. Now in its sixth incarnation, Jasc's *Paint Shop Pro* is the complete Windows solution for arcade game graphics creation.

Simply put, if you're interested in a program that offers 90% of the power of Adobe *Photoshop* for one-fifth the price, look no further than this program.

TABLE 6-11: *Paint Shop Pro* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	A vast improvement from previous releases of the program. *Paint Shop Pro* provides intuitive icons and maximizes the available drawing screen.
Performance and stability	Excellent	The program is quick and responsive on all but the slowest systems. Appears very stable on all systems tested.
Compatibility	Excellent	Compatible with all versions of Windows from 95 through Windows 2000.

Criteria	*Rating*	*Comments*
Unique or special features	Excellent	■ Supports a wide array of popular graphic formats, including Macintosh PICT and Photoshop PSD. ■ Supports layers. ■ Compatible with most Adobe *Photoshop* plug-ins. This allows it to support a whole host of powerful third-party special effects filters and export file formats, thus greatly expanding the power of the program. ■ Supports a large number of predefined special effects and allows you to preview them before applying them to your image. ■ Supports the drawing of vectorized geometric shapes. This allows shapes to be easily resized and manipulated without resolution-specific distortion. ■ Allows you to take screen captures from within the program. ■ Provides a command history that allows you to repeat or undo sequences of past program operations. ■ Supports display modes of various color depths and screen resolutions and can promote or reduce colors between different display modes. ■ Can perform batch image conversion, thus, the program can effectively serve as an image viewer/converter program. ■ Can perform gamma correction on images. ■ Can browse your hard drive for images and make image catalogs from them. ■ Comes bundled with a powerful animation utility. ■ Supports all program tools while zoomed. ■ Provides an excellent online help facility.
Cost	Very good	$99 (US) download or $109 (US) for CD version.
Availability and support	Excellent	Easily found online and very well supported. Frequently updated by an established company.
Gripes	Very good	■ Offers a limited gradient fill capability. All of its gradient fill angles are predefined. ■ Tool option dialogs can be a bit annoying. ■ Large program that uses a lot of RAM and disk space.

TABLE 6-12: *Paint Shop Pro* Feature Summary

Drawing Tools and Effects	*Supported*	*Comments*
The Pencil tool	✓	Includes the standard functionality for this tool.
The Brush tool	✓	Provides several brush sizes, shapes, and effects, including charcoal, magic marker, and ink. Also supports multiple brush widths and brush cloning, a feature typically found only in image editors.
The Airbrush tool	✓	Also allows you to control the size and rate of the spray.
The Line tool	✓	Can produce connected line segments and control the width of the line.
The Curve tool	✓	Supports two types of curves: simple and one with multiple endpoints.
The Rectangle tool	✓	Can produce both filled and unfilled rectangles as well as squares.
The Ellipse tool	✓	Can produce filled and unfilled ellipses as well as rotated ellipses.
The Polygon tool	✓	Can produce both filled and unfilled polygon shapes as well as gradient fills. Also lets you create basic 3D shapes.
The Fill tool	✓	Lets you fill in areas with solid colors, patterns, and gradient fills. Also allows you to fill in objects using straight, shaped, ridged, radial, and contoured gradients but doesn't allow you to adjust the fill angle.
The Selection tool	✓	Includes the standard functionality for this tool and supports a number of image block manipulation functions.
The Lasso tool	✓	Includes the standard functionality for this tool and supports a number of image block manipulation functions.
The Zoom tool	✓	Lets you magnify screen sections from 2 to 32 times their original size. Allows access to all tools while zoomed.
The Navigator tool	✓	Includes the standard functionality for this tool.
The Eye Dropper tool	✓	Includes the standard functionality for this tool.
The Palette Selector tool	✓	Includes the standard functionality for this tool. Supports the Microsoft PAL format.
Brighten	✓	Allows you to brighten regions as well as the entire image.
Darken	✓	Allows you to darken regions as well as the entire image.

Drawing Tools and Effects	*Supported*	*Comments*
Smooth	✓	Allows you to smooth regions as well as the entire image.
Smear	✓	Includes the standard functionality for this tool.
Invert		Not implemented but can be simulated via one of its special effect options.
The Translucency tool		Not implemented but can be simulated with layers.
The Stencil tool	✓	Doesn't support color-based stencils but does support screen masks in higher color display modes.
The Anti-alias tool		Not implemented.
The Colorize tool	✓	Doesn't work the same way it does in *Deluxe Paint* or other programs mentioned here as it's only supported in block operation and not as a toggle/modifier as with other painting programs.
The Shade tool		Not implemented.
The Grid tool	✓	Supports variable sized grids but offers no "snap-to-grid" function.
The Eraser tool	✓	Includes the standard functionality for this tool.
The Clear tool	✓	Includes the standard functionality for this tool.
The Undo tool	✓	Includes the standard functionality for this tool. Doesn't support an undoable Undo but does support an undo history.
The Text tool	✓	Includes the standard functionality for this tool. Allows you to anti-alias text and treat text as a block selection for further manipulation. Supports Windows TrueType fonts. Includes the ability to adjust kerning and leading.
Industry standard file formats	✓	Can load BMP, PNG, JPEG, GIF 87a/89a, IFF/LBM, PSP, PSD, PCX, TIFF, TGA, and Macintosh PICT. Can save BMP, PNG, GIF 87a/89a, PSP, PSD, PCX, JPEG, IFF/LBM, TIFF, TGA, and Macintosh PICT. The accompanying animation utility can also export FLIC files.
Multiple display mode support	✓	Supports all display modes supported by Windows and your video hardware.
Multiple screen support	✓	Available work screens are limited only by available memory.
Keyboard shortcuts	✓	Makes extensive use of keyboard shortcuts.
Coordinate tracking	✓	Includes the standard functionality for this tool.

NOTE: You can find a fully functional trial version of *Paint Shop Pro* on the CD-ROM included in this book. Please refer to Appendix B for more information.

Pro Motion

Latest Version (at time of writing): 4.2

Native Platform: Windows 95, 98, NT 4.0, and 2000

Type: Commercial

Publisher/Author: Cosmigo, Inc.

System Requirements: PC compatible, Windows 95, 98, or NT 4.0, and an SVGA graphics card

URL (at time of writing): http://www.cosmigo.com/promotion/

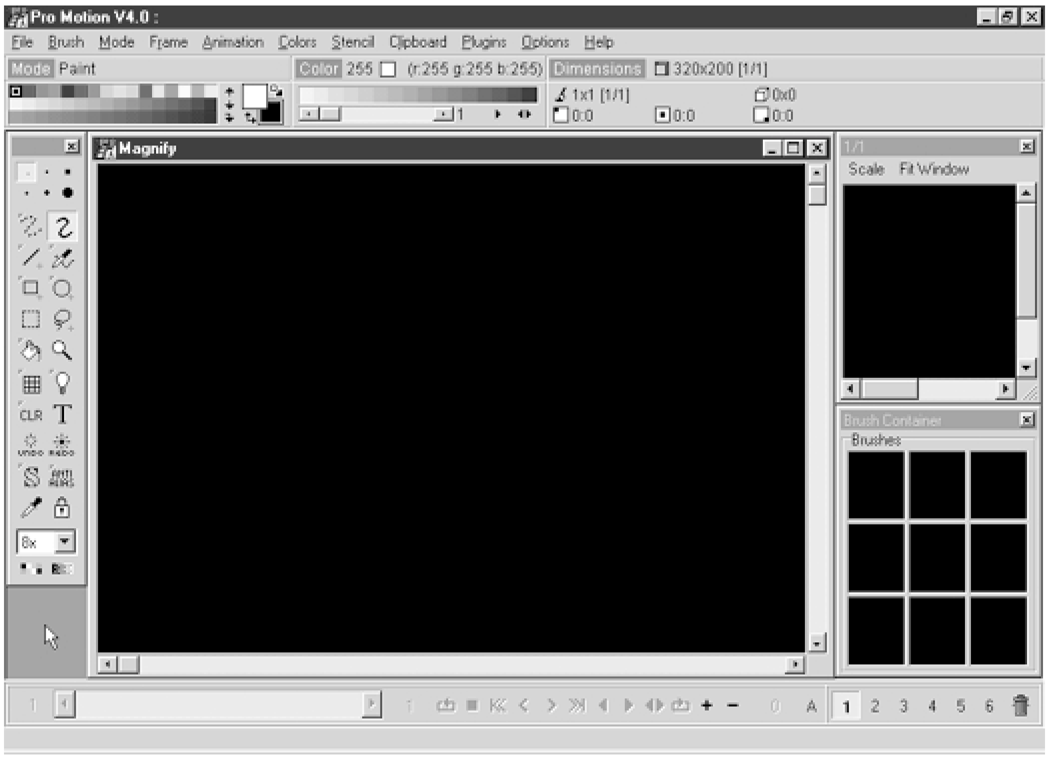


FIGURE 6-7: *Pro Motion*

Pro Motion is a Windows-based painting program that was closely modeled after *Deluxe Paint V* for the Commodore Amiga. It first appeared on the market in 1996 and has earned a good reputation as a game graphics creation tool with both hobbyists and professional game developers alike.

If you're serious about designing arcade game graphics, definitely get *Pro Motion*.

TABLE 6-13: *Pro Motion* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	Interface is very intuitive. Screen is relatively uncluttered. Most options have icons associated with them and all work as expected.
Performance and stability	Excellent	Runs well on even the slowest of machines. Faster machines will enjoy even better performance. Noticeably stable on the systems tested.
Compatibility	Very good	Fully compatible with all 32-bit versions of Windows from Windows 95 through Windows 2000.
Unique or special features	Excellent	■ Provides all of *Deluxe Paint*'s painting tools and functionality. ■ Includes a sophisticated, built-in animation tool. ■ Supports multiple levels of undoable undos. ■ Supports all program tools while zoomed. ■ Supports all popular file formats. ■ Supports plug-ins, which can extend the functionality of the program even further. ■ Provides a simple but effective help facility.
Cost	Very good	$58 (US) e-mail version or $74 (US) for the program on CD.
Availability and support	Excellent	Easily found online and very well supported by its author. Updated frequently and updates are free.
Gripes	Very good	■ Anti-alias function isn't as robust as some of the other programs mentioned here, particularly when dealing with text. ■ Only supports six work screens. ■ Handles Windows Clipboard access in a non-standard way.

TABLE 6-14: *Pro Motion* Feature Summary

Drawing Tools and Effects	*Supported*	*Comments*
The Pencil tool		Not implemented. However, its Brush tool offers something similar.
The Brush tool	✓	Also supports multiple brush widths.
The Airbrush tool	✓	Allows you to control the size of the spray.

Drawing Tools and Effects	*Supported*	*Comments*
The Line tool	✓	Also allows you to created connected line segments and control the width of the line.
The Curve tool	✓	Supports two types of curves: simple and one with multiple endpoints.
The Rectangle tool	✓	Lets you draw both filled and unfilled rectangles as well as squares.
The Ellipse tool	✓	Lets you draw filled and unfilled ellipses.
The Polygon tool	✓	Allows you to draw both filled and unfilled polygon shapes.
The Fill tool	✓	Lets you fill in areas with solid colors, patterns, and gradient fills. Also allows you to fill in objects using straight, shaped, ridged, radial, and contoured gradients with full control over the fill angle.
The Selection tool	✓	In addition to the standard functions such as cut, copy, and paste, this program supports block resizing, rotation, bending, shearing, halving, doubling, flipping, and converting objects into single colors, as well as loading and saving blocks.
The Lasso tool	✓	Same features as the Selection tool.
The Zoom tool	✓	Lets you magnify screen sections from 2 to 32 times their original size. Also allows you to use all tools while in magnification mode.
The Navigator tool	✓	Allows you to view the entire screen at once but uses a crude form of this tool.
The Eye Dropper tool	✓	Includes the standard functionality for this tool.
The Palette Selector tool	✓	Provides all major features including the ability to define colors, swap color values, copy color values, and define color gradients. It even allows you to load and save color palettes in the Microsoft .PAL format.
Brighten	✓	Includes the standard functionality for this tool.
Darken	✓	Includes the standard functionality for this tool.
Smooth	✓	Includes the standard functionality for this tool.
Smear	✓	Includes the standard functionality for this tool.
Invert	✓	Includes the standard functionality for this tool.
The Translucency tool	✓	Allows you to specify the level of translucency.
The Stencil tool	✓	Includes a powerful Stencil function that gives you full control over individual colors and the ability to load and save stencils for future use.
The Anti-alias tool	✓	Provides two algorithms of anti-aliasing for different situations and works with all drawing tools.

Drawing Tools and Effects	*Supported*	*Comments*
The Colorize tool	✓	Works exceptionally well, particularly on color gradients of the same intensity.
The Shade tool	✓	Includes the standard functionality for this tool.
The Grid tool	✓	Includes the standard functionality for this tool.
The Eraser tool		Not implemented.
The Clear tool	✓	Includes the standard functionality for this tool.
The Undo tool	✓	Supports an undoable Undo and can even redo actions up to several levels.
The Text tool	✓	Supports full text editing capabilities and compatible with Windows TrueType fonts. Doesn't support leading, kerning, or tracking control.
Industry standard file formats	✓	Reads and writes BMP, GIF 87a, IFF/LBM, and PCX files. Its animation tool can also import and export files in the FLIC format.
Multiple display mode support	✓	Limited to 8-bit (256 color) display modes in all standard Windows screen resolutions.
Multiple screen support	✓	Only supports a maximum of six work screens regardless of available memory.
Keyboard shortcuts	✓	Makes extensive use of keyboard shortcuts. Many of these are logically assigned and some even mirror shortcuts used by *Deluxe Paint*.
Coordinate tracking	✓	Includes the standard functionality for this tool.

NOTE: You can find a feature-disabled demonstration version of *Pro Motion* on the CD-ROM included with this book. Please refer to Appendix B for more information.

Other Useful Windows Painting Programs

There were a number of Windows-based painting programs that met most of my review criteria but ultimately weren't recommended for various reasons. Nevertheless, they are mentioned here.

- *ArtGem*—An interesting true color painting program. Although a capable program, its strange interface makes me prefer other programs.
- *ChaosFX*—A feature-rich image editing program. The program is technically very impressive but very expensive when compared to most of the other programs reviewed in this section of the chapter.

- *Pixel 32*—An incredibly promising image editor that is still under development and not completely stable at this time. However, once this program is completed, it will give programs such as *Paint Shop Pro* and *Photoshop* a real run for the money.
- *Ultimate Paint*—A general-purpose painting program. While the program is stable and inexpensive, it's not nearly as feature rich or easy to use as many of the other programs reviewed here.

NOTE: Some or all of these programs are included on the book's accompanying CD-ROM. Refer to Appendix B for additional details.

Recommended DOS Screen Capture Utilities

- *Screen Thief*

Screen Thief

Latest Version (at time of writing): 2.04

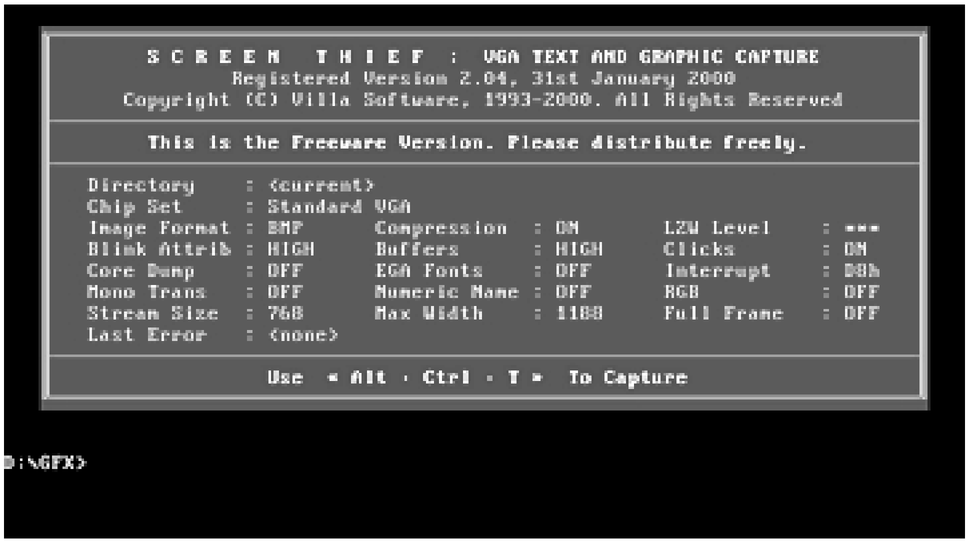
Native Platform: DOS

Type: Freeware

Publisher/Author: Villa Software, Inc.

System Requirements: PC compatible, DOS, Windows 95 and 98, and a VGA graphics card

URL (at time of writing): http://www.villasoftware.com



```
           S C R E E N   T H I E F  :  VGA TEXT AND GRAPHIC CAPTURE
                 Registered Version 2.04, 31st January 2000
           Copyright (C) Villa Software, 1993-2000. All Rights Reserved

             This is the Freeware Version. Please distribute freely.

   Directory    : <current>
   Chip Set     : Standard VGA
   Image Format : BMP      Compression  : ON       LZW Level    : ***
   Blink Attrib : HIGH     Buffers      : HIGH     Clicks       : ON
   Core Dump    : OFF      EGA Fonts    : OFF      Interrupt    : 08h
   Mono Trans   : OFF      Numeric Name : OFF      RGB          : OFF
   Stream Size  : 768      Max Width    : 1188     Full Frame   : OFF
   Last Error   : <none>

                       Use « Alt · Ctrl · T »  To Capture

D:\GFX>
```

FIGURE 6-8: *Screen Thief*

Screen Thief is a full-featured DOS screen capture utility that's been around since the early 1990s. It has become popular with game developers due to its reliability, feature set, and ability to capture screen displays that other capture programs could not.

If you need to capture DOS game screens, this is the program to use.

TABLE 6-15: *Screen Thief* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Good	Very easy to use for a pure DOS program. Default capture keys are easy to access and intuitive to use.
Performance and stability	Very good	Worked as advertised with good performance. Very stable.
Compatibility	Good	Runs flawlessly under DOS and Windows 95. Not tested under Windows NT, however.
Unique or special features	Very good	■ Provides support for most common graphic file formats ■ Allows user to redefine capture keys, which makes it very flexible. ■ Can redefine its interrupt for maximum compatibility with other DOS TSR software.
Cost	Excellent	Free.
Availability and support	Good	Can be found online relatively easily. Still supported but not frequently updated.
Gripes	Good	■ Requires you to configure it manually via the command line to support special features and display modes. ■ Has trouble capturing some screens that use SVGA compatible display modes.

TABLE 6-16: *Screen Thief* Feature Summary

Program Features	Supported	Comments
Full screen capture	✓	Can successfully capture screens in most VGA and SVGA display modes.
Active windows capture	N/A	N/A
Region capture		Not implemented.
DOS screen capture	✓	Works as expected.
DirectX capture	N/A	N/A
Standard file formats	✓	Can capture screens and save them in PCX, TIFF, BMP, and GIF file formats.
Clipboard access	N/A	N/A
Capture undo		Not implemented.

Program Features	Supported	Comments
Automatic palette correction	N/A	N/A
Image cropping		Not implemented.

NOTE: You can find a copy of *Screen Thief* on the CD-ROM that accompanies this book. Please refer to Appendix B for more information.

Recommended Windows Screen Capture Utilities

- *HyperSnapDX*
- *Snagit*

HyperSnapDX

Latest Version (at time of writing): 3.55

Native Platform: Windows 95, 98, NT 4.0, and 2000

Type: Shareware

Publisher/Author: Hyperionics

System Requirements: PC compatible, DOS, Windows 95, 98, NT 4.0, or 2000, and an SVGA graphics card

URL (at time of writing): http://www.hypersnap-dx.com/hsdx/

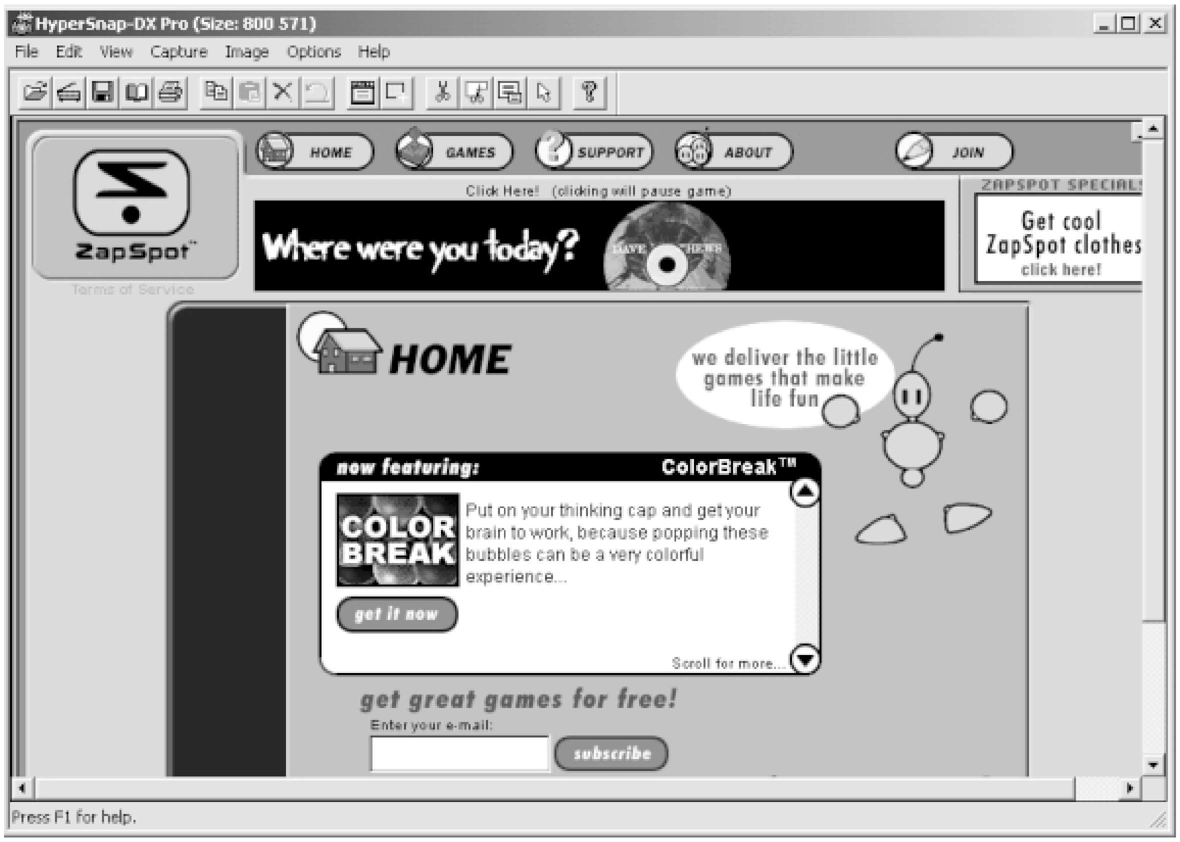

HyperSnap-DX Pro (Size: 800 571)
File Edit View Capture Image Options Help
HOME
GAMES
SUPPORT
ABOUT
JOIN
Click Here! (clicking will pause game)
Where were you today?
ZAPSPOT SPECIALS
Get cool ZapSpot clothes click here!
ZapSpot
HOME
we deliver the little games that make life fun
now featuring: ColorBreak™
COLOR BREAK
Put on your thinking cap and get your brain to work, because popping these bubbles can be a very colorful experience...
get it now
Scroll for more...
get great games for free!
Enter your e-mail:
subscribe
Press F1 for help.

FIGURE 6-9: *HyperSnapDX*

HyperSnapDX is an extremely impressive and powerful screen capture utility. It can capture virtually any Windows screen including those used by DirectX and 3Dfx Glide games. Furthermore, it can save captured images in any of 20 different graphic file formats.

HyperSnapDX is one screen capture utility that belongs in every game developer's toolbox.

TABLE 6-17: *HyperSnapDX* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	Very easy to use and default capture keys are easy to access.
Performance and stability	Excellent	Worked as advertised with great performance on all systems on which it was tested. A very stable and reliable program.
Compatibility	Excellent	Runs flawlessly under Windows 95, 98, NT 4.0, and 2000.

Criteria	*Rating*	*Comments*
Unique or special features	Excellent	■ Supports over 20 common graphic file formats including PSD. ■ Allows user to redefine capture keys, which makes it very flexible. ■ Can capture DirectX and 3Dfx Glide game screens. ■ Can capture the entire scrolling contents of a screen window. ■ Supports many common image manipulation functions such as resizing and changing color depth and resolution.
Cost	Excellent	$25 (US)
Availability and support	Excellent	Easily found online, well supported, and frequently updated and enhanced.
Gripes	Very good	■ Doesn't capture DOS screens.

TABLE 6-18: *HyperSnapDX* Feature Summary

Program Features	*Supported*	*Comments*
Full screen capture	✓	Allows you to capture any Windows-compatible display mode supported by your system.
Active windows capture	✓	Works as expected.
Region capture	✓	Works as expected. Supports coordinate tracking in order to help you make more precise region captures.
DOS screen capture		Not implemented.
DirectX capture	✓	Works as expected.
Standard file formats	✓	Can capture screens and save them in PCX, TIFF, BMP, PSD, GIF, PNG, and a number of other file formats.
Clipboard access	✓	Works as expected.
Capture undo	✓	Works as expected.
Automatic palette correction	✓	Works as expected.
Image cropping	✓	Works as expected. Provides handy guides that enable you to crop images with pixel-point precision.

NOTE: You can find a fully functional trial version of *HyperSnapDX* on the CD-ROM that accompanies this book. Please refer to Appendix B for more information.

SnagIt Pro

Latest Version (at time of writing): 5.01

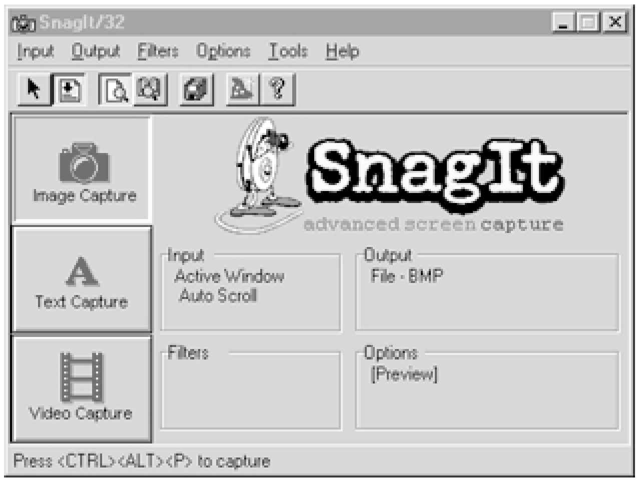
Native Platform: Windows 95, 98, and NT 4.0

Type: Shareware

Publisher/Author: TechSmith, Inc.

System Requirements: PC compatible, DOS, Windows 95, 98, NT 4.0, or 2000, and an SVGA graphics card

URL (at time of writing): http://www.techsmith.com/products/snagit/



Input: Active Window, Auto Scroll
Output: File - BMP
Filters
Options: [Preview]
Press <CTRL><ALT><P> to capture

FIGURE 6-10: *SnagIt*

SnagIt has been around in one form or another since 1990, and like a fine wine, it only gets better with age. This screen capture utility offers a number of powerful and unique screen capture features, including the ability to capture and record screen activity as highly compressed video files. In addition, it's one of the few Windows screen capture utilities that is able to capture full-size DOS screens.

TABLE 6-19: *SnagIt* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	Very easy to use and default capture keys are easy to access.
Performance and stability	Excellent	Worked as advertised with great performance on all systems tested on. A very stable and reliable program.
Compatibility	Excellent	Runs flawlessly under Windows 95, 98, NT 4.0, and 2000.

Criteria	*Rating*	*Comments*
Unique or special features	Excellent	■ Supports all common graphic file formats. ■ Allows user to redefine capture keys, which makes it very flexible. ■ Can capture DOS screens. ■ Can capture screens and save them as Windows AVI videos. ■ Can capture the entire scrolling contents of a window. ■ Supports many common image manipulation functions such as resizing and changing color depth and resolution.
Cost	Excellent	$39.95 (US)
Availability and support	Excellent	Easily found online, well supported, and frequently updated and enhanced.
Gripes	Very good	■ Doesn't allow DirectX screen captures.

TABLE 6-20: *SnagIt* Feature Summary

Program Features	*Supported*	*Comments*
Full screen capture	✓	Allows you to capture any Windows-compatible display mode supported by your system.
Active windows capture	✓	Works as expected.
Region capture	✓	Works as expected. Supports coordinate tracking in order to help you make more precise region captures.
DOS screen capture	✓	Can capture most DOS screens, even when running a full DOS session.
DirectX capture		Not implemented.
Standard file formats	✓	Can capture screens and save them in PCX, TIFF, BMP, GIF, PNG, and a number of other file formats.
Clipboard access	✓	Works as expected.
Capture undo	✓	Works as expected.
Automatic palette correction	✓	Works as expected.
Image cropping	✓	Works as expected.

NOTE: You can find a fully functional trial version of *SnagIt* on the CD-ROM that accompanies this book. Please refer to Appendix B for more information.

Recommended DOS Image Viewers/Converters

- *SEA*

SEA

Latest Version (at time of writing): 1.3

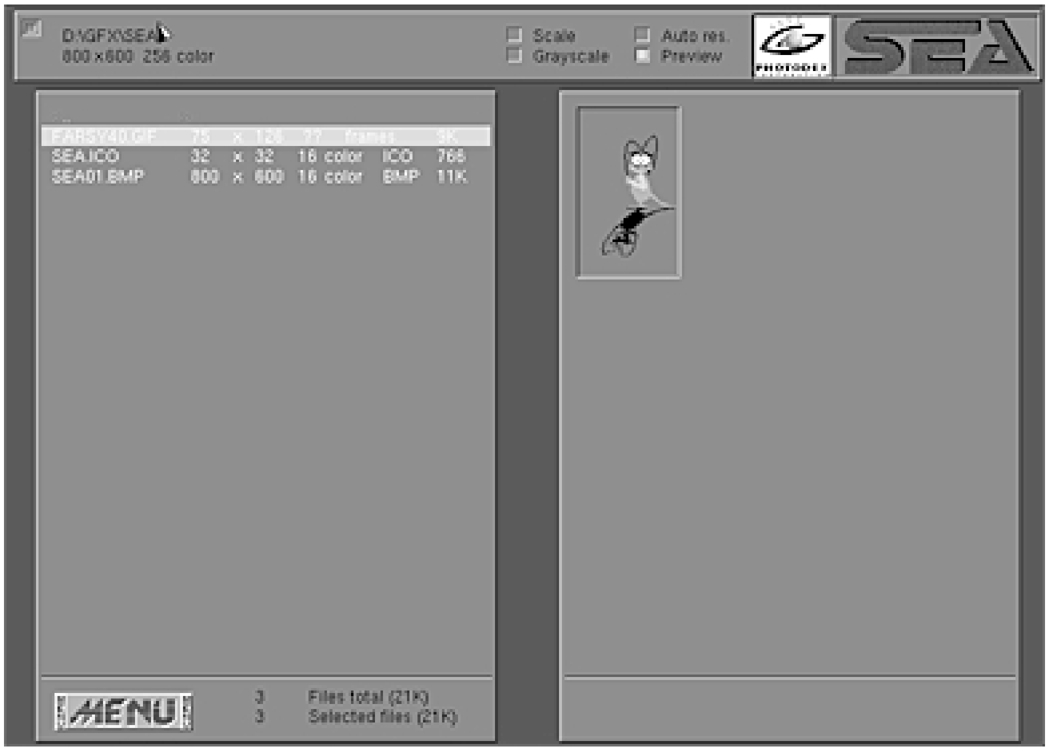
Native Platform: DOS

Type: Shareware

Publisher/Author: Photodex Corporation

System Requirements: A 386 with 4MB, a VESA-compatible 1 MB VGA card, and a mouse (optional)

URL (at time of writing): http://www.photodex.com



```
D:\GFX\SEA
800 x 600  256 color

FARSY40.GIF    75  x 126   ??  frames      9K
SEA.ICO        32  x  32   16 color   ICO  766
SEA01.BMP     800  x 600   16 color   BMP  11K

3    Files total (21K)
3    Selected files (21K)
```

FIGURE 6-11: *SEA*

SEA achieves what has often been thought impossible under DOS: it marries an easy-to-use and attractive user interface with a solid image viewing and conversion engine.

If you're a DOS user, this is <u>the</u> image viewer/converter program to have.

TABLE 6-21: *SEA* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	The best of any DOS-based graphics program of its type. Menu commands are clearly labeled and intuitive, making it easy to use.
Performance and stability	Excellent	Runs very well on all tested systems. Fastest of all of the DOS image viewers I've used. Appears to be very stable and reliable.
Compatibility	Very good	Runs on DOS and Windows 95 and 98. Will not run on Windows NT 4.0, however.
Unique or special features	Good	■ Supports command line driven image viewing and conversion. ■ One of the few DOS-based image viewers to support PSD files. ■ Supports all SVGA display modes with the appropriate VESA drivers installed.
Cost	Very good	$29.95 (US)
Availability and support	Good	Easily obtainable and reasonably well supported. Updated occasionally.
Gripes	Good	■ Should support more graphic file formats.

TABLE 6-22: *SEA* Feature Summary

Program Features	*Supported*	*Comments*
Extensive graphics file format support	✓	Supports all standard image formats such as GIF, JPEG, PNG, TIFF, PCX, PSD, IFF/LBM, and TGA.
Good interface	✓	Excellent interface. A real joy to use.
Batch conversions	✓	Works as expected but not as efficient or elegant as some of the other programs described here.
Image catalogs	✓	Works as expected.
Special operations	✓	Performs many special operations including image resizing, color reduction, and gamma correction.

Other Useful DOS Image Viewers/Converters

There were a number of DOS-based image viewers/converters that met most of my review criteria but weren't reviewed here for various reasons. Nevertheless, I will mention them here as you may find them useful. These are:

- *Display*—A free image viewing and conversion utility that provides many features and options. Its only drawbacks are its large memory requirements and complex user interface.
- *Graphics Workshop for DOS*—A very reliable, shareware image viewing and conversion utility. This program was written by Steven William Rimmer, one of the leading authorities on graphic file formats.
- *Nview*—A DOS version of *XNView* (which is described in the next section) that utilizes the same image viewing/conversion engine. Unfortunately, there were compatibility problems that prevented it from running properly on my test system.

NOTE: Some or all of these programs are included on the book's accompanying CD-ROM. Refer to Appendix B for additional details.

Recommended Windows Image Viewers/Converters

- *IrfanView*
- *XNView*

IrfanView

Latest Version (at time of writing): 3.17
Native Platform: Windows 95, 98, and NT 4.0
Type: Freeware
Publisher/Author: Irfan Skiljan
System Requirements: PC compatible, Windows 95, 98, NT 4.0, or 2000, and an SVGA graphics card
URL (at time of writing): http://stud1.tuwien.ac.at/~e9227474

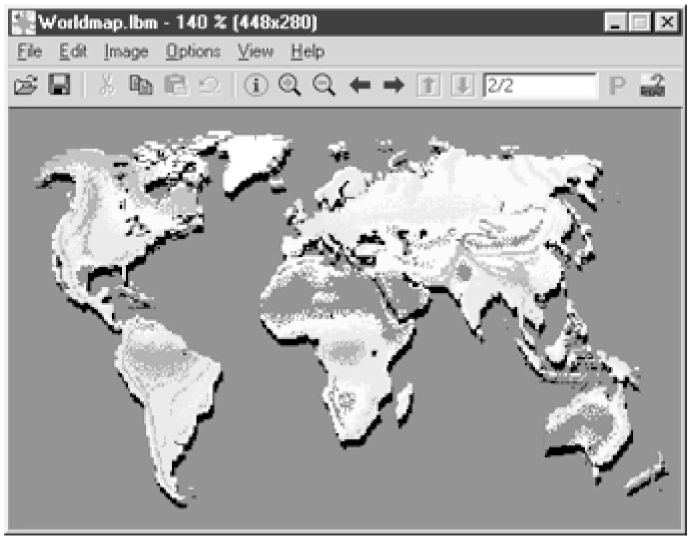

Worldmap.lbm - 140 % (448x280)
File Edit Image Options View Help
2/2

FIGURE 6-12: *IrfanView*

IrfanView 32 started out three years ago as a hobbyist project by a talented university student named Irfan Skiljan and has quickly established itself as one of the best programs of its type—free or commercial. *IrfanView 32* supports dozens of graphic file formats, special effects, and image conversion options, and provides many other features that few other programs of its type can touch.

I highly recommend this program as much for its features as its price.

TABLE 6-23: *IrfanView* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Very good	Easy to use but tries to pack too much functionality in too little an area. Some options are crowded and confusing.
Performance	Excellent	Performs very well on all systems tested. Displays images quickly.
Compatibility	Excellent	Runs without incident on all Windows 95, 98, NT 4.0, and 2000 systems.
Unique or special features	Excellent	■ Supports over 70 different graphic file formats, including all of the file formats mentioned in Chapter 3. ■ Can do batch image conversions. ■ Can double as a screen capture utility. ■ Can create browsable thumbnails of all of the images in a given directory. ■ Can count the number of colors used by a particular image. ■ Can install itself as your default Windows graphic viewer.

Criteria	*Rating*	*Comments*
Cost	Excellent	Free.
Availability and support	Excellent	Easy to obtain and well supported. Updated frequently.
Gripes	Very good	■ Tries to do a bit too much for a program of its type. This means that many of its menu options are cluttered.

TABLE 6-24: *IrfanView* Feature Summary

Program Features	Supported	Comments
Extensive graphics file format support	✓	Compatible with all common graphic file formats and then some.
Good interface	✓	Interface is relatively easy to use.
Batch conversions	✓	Works as expected. Performs conversion actions quickly.
Image catalogs	✓	Works as expected.
Special operations	✓	Can perform color depth reduction and promotion, image scaling, and a variety of other useful image processing effects.

NOTE: You can find a copy of *IrfanView* on the CD-ROM that accompanies this book. Please refer to Appendix B for more information.

XNView

Latest Version (at time of writing): 1.12

Native Platform: Windows 95, 98, NT 4.0, and 2000

Type: Freeware

Publisher/Author: Pierre Gougelet

System Requirements: PC compatible, Windows 95, 98, NT 4.0, or 2000, and an SVGA graphics card

URL (at time of writing): http://perso.wanadoo.fr/pierre.g/

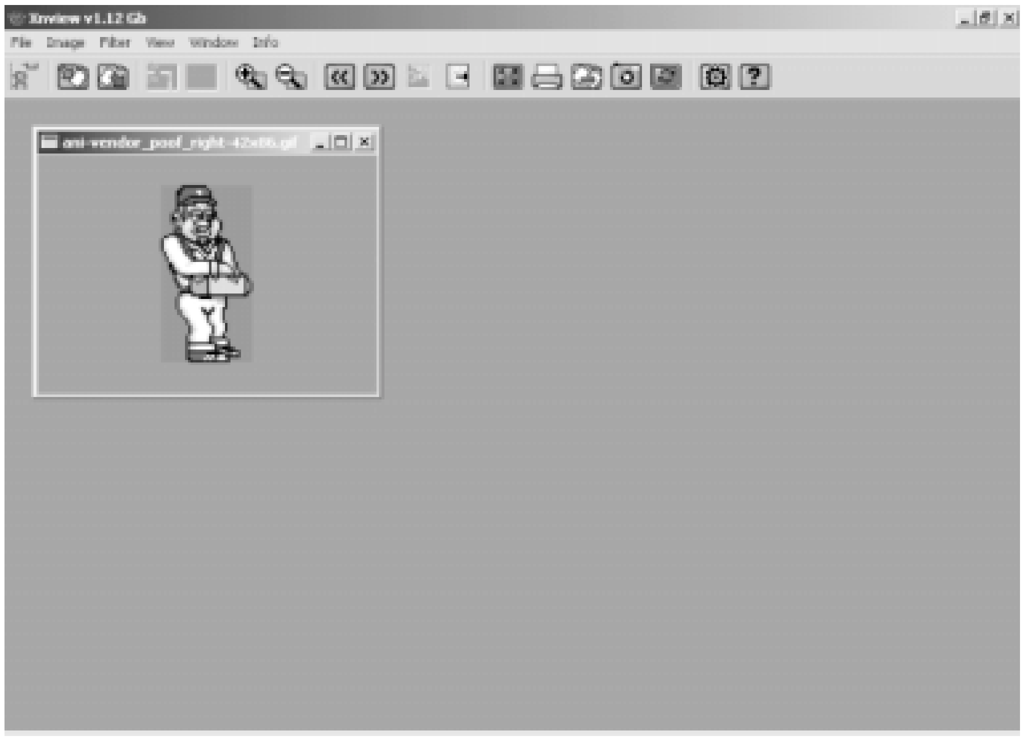

Xnview v1.12 Gb
File Image Filter View Window Info
ani-vendor_pool_right-42x66.gif

FIGURE 6-13: *XNView*

XNView has been around in one form or another since the early 1990s. Since that time it has been ported to platforms as diverse as the Atari ST to Linux.

It's also one of the most impressive image viewing and conversion programs I've ever seen as it supports over 120 different graphic file formats and sports a refreshingly simply and effective user interface.

If you're looking for a reliable and feature-rich image viewer/converter, definitely consider using *XNView*.

TABLE 6-25: *XNView* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Excellent	Intuitive and very easy to use. Makes good use of icons and all options are clearly labeled.
Performance and stability	Excellent	Performs very well on all systems tested. Displays images quickly. Appears to be very stable.
Compatibility	Excellent	Runs well on all Windows 95, 98, NT 4.0, and 2000 systems tested.

Criteria	*Rating*	*Comments*
Unique or special features	Excellent	■ Supports over 120 different graphic file formats, including all of the file formats mentioned in Chapter 3. ■ Can do batch image conversions while applying special effects. ■ Can double as a screen capture utility when needed. ■ Can create browsable thumbnails of all of the images in a given directory. ■ Can count the number of colors used by a particular image. ■ Can install itself as your default Windows graphic viewer.
Cost	Excellent	Free.
Availability and support	Excellent	Easy to obtain and well supported. Updated occasionally.
Gripes	Excellent	None.

TABLE 6-26: *XNView* Feature Summary

Program Features	Supported	Comments
Extensive graphics file format support	✓	Compatible with all common graphic file formats and then some.
Good interface	✓	Interface is very easy to use.
Batch conversions	✓	Very flexible.
Image catalogs	✓	Works as expected.
Special operations	✓	Can perform color depth reduction and promotion, image scaling, and a variety of sophisticated image processing effects. Can even apply these operations to images as it converts them from one format to another.

NOTE: You can find a copy of *XNView* on the CD-ROM that accompanies this book. Please refer to Appendix B for more information.

Other Useful Windows Image Viewers/Converters

There were a number of Windows-based image viewers/converters that met most of my review criteria but weren't reviewed here for various reasons. Nevertheless, I will mention them here as you may find them useful. These programs include:

- *CompuPic*—A commercial image viewing and conversion utility. Provides many useful features and has an excellent user interface.

- *Graphics Workshop Pro*—A very well written shareware image viewing and conversion utility. Offers many features and options including the ability to save images as executable programs. This program was also written by Steven William Rimmer, one of the leading authorities on graphic file formats.

NOTE: These programs are included on the book's accompanying CD-ROM. Refer to Appendix B for additional details.

Recommended Palette Tools

- *Opal*
- *PalMerge*

Opal

Latest Version (at time of writing): 1.95

Native Platform: Windows 95, 98, and NT 4.0

Type: Shareware

Publisher/Author: Basta Computing, Inc.

System Requirements: PC compatible, Windows 95, 98, or NT 4.0, and an SVGA graphics card

URL (at time of writing): http://www.basta.com

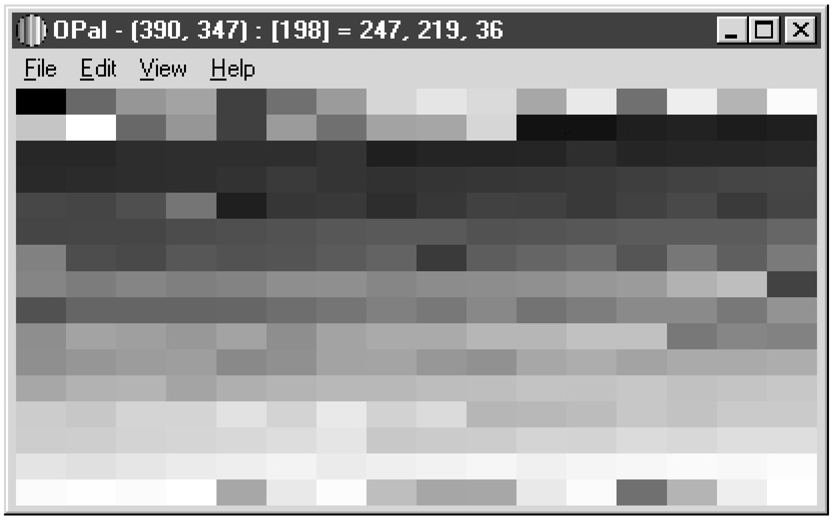


FIGURE 6-14: *Opal*

Opal enables you to perform several different types of color palette manipulations. These include looking up the RGB value and palette index of any pixel on the desktop, capturing the palette of another application, and saving the contents of the current color palette to a bitmap image or text file.

TABLE 6-27: *Opal* Overview

Criteria	Rating	Comments
Interface and ease of use	Excellent	Very easy to use. The program's options are logically arranged and well thought out.
Performance and stability	Excellent	Runs well on all Windows systems tested. Appears to be very stable.
Compatibility	Excellent	Compatible with Windows 95, 98, and NT 4.0.
Unique or special features	Good	■ Allows you to export the contents of the current color palette to a text file. This can be very useful for designers and programmers alike. ■ Can describe color values in a variety of formats.
Cost	Excellent	$10 (US)
Availability and support	Good	Easily found online and well supported. However, it is only occasionally updated.
Gripes	Poor	■ Doesn't allow you to alter the color palette or perform color palette manipulations of any sort. ■ Limited use in non-palette display modes.

TABLE 6-28: *Opal* Feature Summary

Program Features	*Supported*	*Comments*
Color palette editing		Not implemented.
Color palette extraction from bitmaps	✓	Only reads palette data from BMP files.
Palette construction from input files		Not implemented.
Common file format support	✓	Only reads palette data from BMP files.

PalMerge

Latest Version (at time of writing): 3.0a

Native Platform: Windows 95, 98, and NT 4.0

Type: Shareware

Publisher/Author: Bryan Miller

System Requirements: PC compatible, Windows 95, 98, or NT 4.0, and an SVGA graphics card

URL (at time of writing): http://www.allcity.net/~vantageview

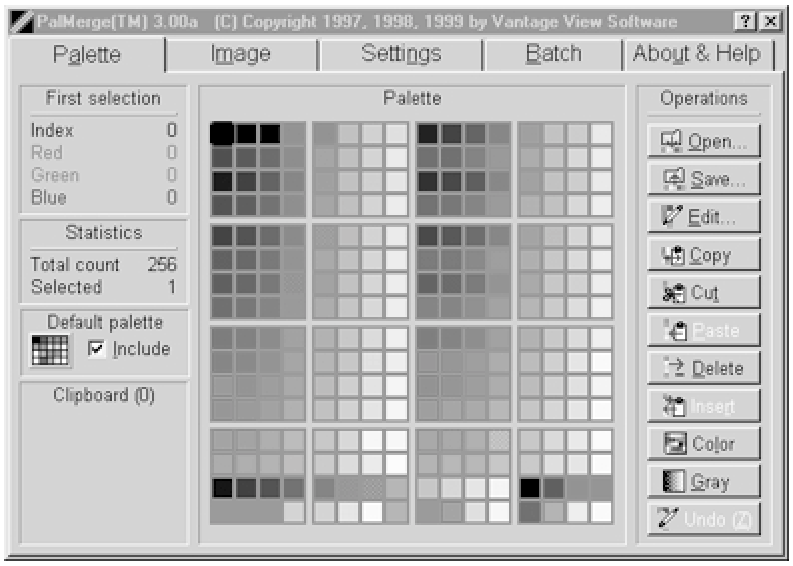


FIGURE 6-15: *PalMerge*

PalMerge is a program designed to give you full control over the contents of the color palette under Windows. Among its special features is a first-rate color palette editor and the ability to extract color palettes from images, and view and process images in various file formats.

Although it won't replace the color selection tools available in most painting programs, *PalMerge* is a good supplemental utility, which many game developers need, and it performs operations that many graphics utilities can't.

TABLE 6-29: *PalMerge* Overview

Criteria	*Rating*	*Comments*
Interface and ease of use	Very good	Relatively easy to use but incorporates several non-standard or outdated Windows interface elements.
Performance	Excellent	Runs well on all Windows systems tested. Appears to be very stable.
Compatibility	Excellent	Compatible with Windows 95, 98, and NT 4.0.

Criteria	*Rating*	*Comments*
Unique or special features	Excellent	■ Can merge the contents of several palettes into one. ■ Can add Windows reserved colors to the palette. ■ Can perform color reduction and palette remapping operations on individual images or in batch. ■ Comes with a number of predefined color palettes to experiment with. ■ Can export palette data in the Microsoft .PAL format.
Cost	Very good	$17 (US)
Availability and support	Excellent	Easily obtainable online. Supported but not updated very often.
Gripes	Good	■ Tries to do too much in one program. It's very good at palette manipulation but less so as an image viewer or conversion utility.

TABLE 6-30: *PalMerge* Feature Summary

Program Features	*Supported*	*Comments*
Color palette editing	✓	Works as expected. Uses Windows' palette editor but does support impressive color copying and pasting abilities.
Color palette extraction from bitmaps	✓	Works as expected. Can extract palettes from BMP and save them in Microsoft .PAL format.
Palette construction from input files	✓	Works as expected.
Common file format support	✓	Supports all standard file formats including .bmp.

NOTE: These programs, as well as several DOS palette tools, are included on the book's accompanying CD-ROM. Refer to Appendix B for additional details.

Other Useful Graphics Utilities

Besides the programs discussed here, the accompanying CD-ROM includes a number of other useful graphics programs and utilities. Of these, two programs really stand out as useful additions to any arcade game developer/designer's creative toolbox. These programs are:

- *MkExpl 3.0* by Lennart Steinke
- *Universe v1.6* by Diard Software

MkExpl 3.0

MkExpl is a DOS-based program that allows you to create a variety of high-quality animated explosion effects. The program takes parameters and then saves the generated sequence into a sequence of .PCX format files. With this program, you never have to go to the trouble of designing explosion effects again! Best of all, this program is free! Figure 6-16 shows an example of the effects this program can create.

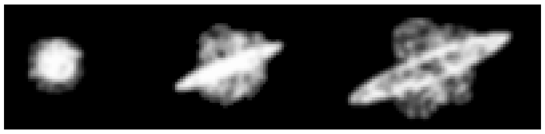


FIGURE 6-16: Example Output of *MkExpl 3.0*

Universe 1.6

Universe is a Windows program that allows you to visually create sophisticated outer space scenes and backgrounds. It allows you to plot realistic looking star fields, nebulas, lens flares, galaxy formations, vortexes, and even several types of planets! The images it generates are suitable for use in virtually any type of space-oriented arcade game. Universe is a shareware program and well worth the price, considering the hours it can save you in design time! Figure 6-17 illustrates just what can be achieved with this amazing program.

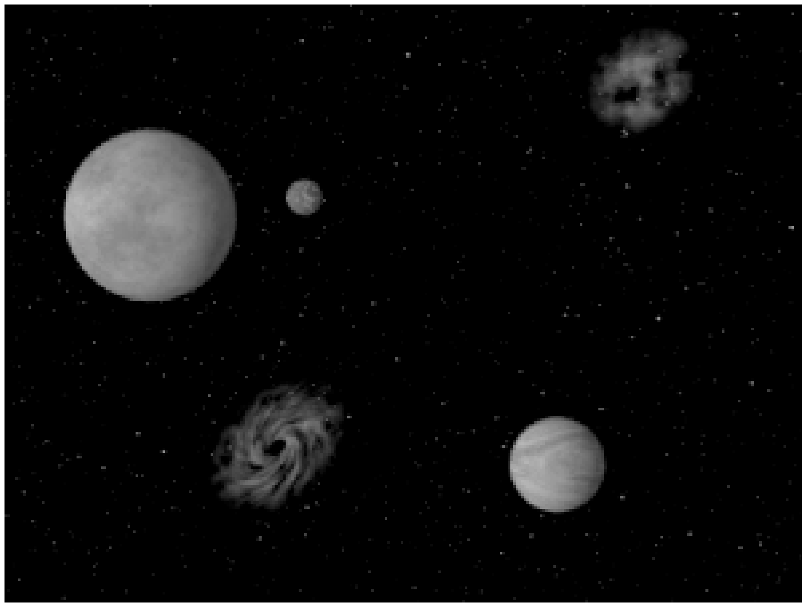


FIGURE 6-17: Example Output of *Universe v1.6*

Chapter 7

Color and Arcade Game Graphics

In this chapter, you'll learn about:

- **Basic color theory**
- **Color mixing**
- **The language and meaning of color**
- **Color perception issues**
- **Volume, light, and shadow**
- **Transparency, translucency, and opacity**
- **Bounding colors**
- **Color and arcade game design styles**
- **General rules for using color in arcade games**

Color is extremely important to arcade game graphics design. When used correctly, color can produce a variety of powerful physical and emotional effects in games. Among other things, we can use color to:

- **Attract the user's attention**—Color can make game objects "pop" or stand out to the user.
- **Alter the user's mood and feelings**—Color can alter and affect the user's mood and emotions. For example, bright colors can induce cheer or happiness while darker colors can induce fear. It can also be used to convey cultural or gender-specific messages.
- **Alter the user's perception of space**—Color can add depth and dimension to objects and scenes. Essentially, color can make things seem more "real" to the user and can project 3D properties onto 2D images by manipulating the user's perception.
- **Create aesthetic appeal**—Color can make objects and scenes seem more enticing, which can stimulate the user's interest and enhance their enjoyment.
- **Show and accentuate similarities and differences**—Color can highlight the similarities and differences between game objects. For example, you can use color to emphasize one object and de-emphasize another such as in a menu or title screen.

As you can see, color is an extremely powerful device. However, in order to achieve these results in your own games you must first learn what color is, how it works, how to produce it, and then how best to use it. That's the purpose of the rest of this chapter. There's quite a bit of material, so let's dive right in.

Basic Color Theory

Color exists as wavelengths of light. The sun generates this light and shines it on different objects. All objects, whether they are organic or man-made, absorb some of these wavelengths while reflecting others. Those wavelengths that are reflected reach the retina of the eye and stimulate the brain so that the perception of color is experienced.

The total sum of light (and color) we can see is called the *visible spectrum*. The total number of colors that a computer display can generate is called its *color gamut*. Despite the fact that modern computer displays can produce millions of colors, no computer system can reproduce all of the colors that can be seen with the human eye. This is due to the wide differences of CRT picture tube quality and the impact of room light. Under ideal viewing conditions, scientists estimate that the average human eye can distinguish and perceive anywhere between 1 and 7 million distinct colors. This is pretty important since I mention throughout this book (as do many other authors) that modern computers can generate up to 16.7 million colors. Actually, this is only partially true. The 24-bit RGB hardware color palette creates 16.7 million *machine states* but these do not necessarily correspond to 16.7 million unique colors. The average human eye just can't perceive that many colors.

In addition to the concept of color there is the element of *tone*. Tone measures the lightness or darkness of an image and is subjective in relationship to the other colors that are present in an image. Tone gives color its depth and form. It provides objects with shape and definition as the tonal range of an image runs from light to dark and vice versa. Tone is analogous to a color gradient described elsewhere in these pages. Tone has simple rules: the larger the tonal range, the higher the image quality. Meanwhile, the smaller the tonal range, the lower the image quality. Images with poor tone appear flat and washed out, while images with good tone look smooth and vibrant. High color modes tend to exhibit strong tonal ranges, while low color modes exhibit weak tonal ranges.

But wait, there's more! Every color also has three basic properties: *hue*, *saturation*, and *value*.

Hue is the color being described or produced, such as yellow, black, green, etc. Hue is also known as the *local color* of an object as it will look as expected when viewed close up but can appear quite differently when viewed from a distance. For example, a particular shade of green might appear bluish if you move far away from the computer's display.

Saturation, also called *intensity* or *brightness*, is the strength or weakness exhibited by a given color. In other words, saturation measures the "purity" of a color. On computer displays, saturation is typically specified as a percentage of light. Highly saturated colors display more brilliance, while less saturated colors display more dullness. For example, 100% black would produce a vivid black, while 50% black would produce a shade of gray.

Value simply measures the degree of lightness or darkness, also known as the *tonal range* of a particular hue.

NOTE: Like RGB, hue-saturation-value, or HSV, is yet another method of selecting computer color. It will be described in more detail in Chapter 8.

Color Mixing

At the heart of color theory, whether it's computer generated or not, is the *color wheel*. Think of the color wheel as a circle that contains different colors waiting to be blended together to produce other colors.

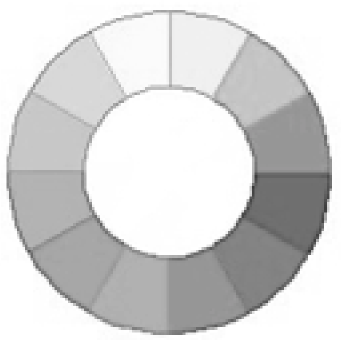


FIGURE 7-1: The Color Wheel

At the most basic level of this model, there are three *primary* or *primitive colors*—red, blue, and yellow on the color wheel. They are called primary because no other colors can be mixed together to create them. They are essentially unique unto themselves.

In addition to the primary colors, there are *secondary colors*. These colors are orange, green, and purple, and are produced by mixing two adjacent primary colors on the color wheel. For example, red + yellow = orange and blue + yellow = green.

Combining primary colors with secondary colors on the color wheel creates *intermediate* or *tertiary colors*. Examples of intermediate colors include yellow-orange, red-orange, yellow-green, blue-green, blue-purple, and red-purple. Intermediate colors are also sometimes referred to as *radical colors*. These colors are frequently found in nature and include such colors as sky blue, olive green, and earth brown.

Once you move beyond mixing primary, secondary, and intermediate colors you experience what are known as *complementary* colors. Complementary colors lie directly opposite from one another on the color wheel. These colors contrast each other because they share no common colors between them. For example, red is complementary to green, orange is complementary to blue, etc. When you combine complementary colors you effectively "cancel out" the complementary colors and produce *neutral* colors. Neutral colors include grays and browns.

The subtle colors we see in most images begin to become apparent as primary, secondary, and tertiary colors are combined and blended ad infinitum. As this happens, a much more sophisticated color wheel evolves. In it, the primary, secondary, and intermediate colors still exist, but there are many thousands or millions of "in between" color shades that become evident as well. It's this color wheel that's the foundation of the color used by computers and in computer arcade games.

On computers, there are two general methods for combining color together electronically. They are known as *additive* and *subtractive* color mixing.

Additive Color Mixing

Red, blue, and green are the primary colors used in the additive color mixing process. When these colors are projected onto each other in equal parts they produce white. Varying the intensities or mixtures of these colors creates other shades of color. For example, black is produced when all traces of red, green, and blue are removed from an image. All computer displays employ a form of additive color mixing to generate their colors.

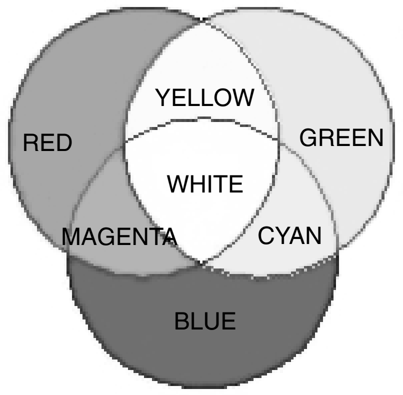


FIGURE 7-2: Additive Color Mixing Diagram

Subtractive Color Mixing

Subtractive color mixing occurs when white light is project on a colored surface and is partially reflected back. The reflected light is the color that we actually see. For example, when sunlight hits a lemon, we see yellow. Unlike additive color mixing, subtractive color mixing isn't based on RGB. Rather it uses cyan-magenta-yellow, or CMY. Mixing these three colors to different degrees produces other colors. For example, black is produced when all three colors are mixed together at 100%. Subtractive color mixing is used almost exclusively in color printing and color photography and is just mentioned here for comparative purposes.

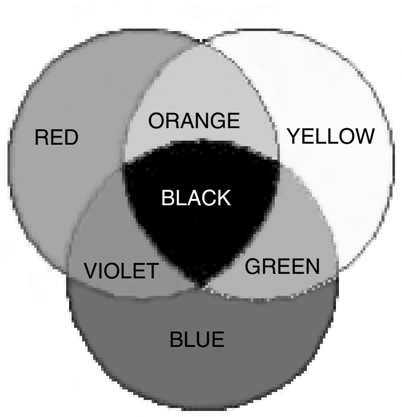


FIGURE 7-3: Subtractive Color Mixing Diagram

Color Temperature

Designers often classify colors by their *temperature*, or their degree of warmness or coolness. Specifically, reds, oranges, and yellows are considered to be warm and exciting, while greens, blues, and violets are considered to be cool and sedating. Warm colors tend to be stimulating, producing the emotional feelings of closeness and friendliness. Cool colors, on the other hand, tend to be soothing, producing the feelings of distance and/or openness.

Understanding these color behaviors can have a major influence on the mood your game artwork projects to the user. For example, a game could use warm colors to represent the heat of an underground lava cave or cool colors to depict a dark forest or a cold iceberg. It's even suggested that warm and cool colors can raise or lower one's body temperature, suggesting a physical connection with the use of color in addition to the emotional one.

Once you grasp the fundamentals of color mixing, you'll be in good shape when it comes time to define your own. Yet, before we learn how to do this, it would be helpful if you understood the hidden language of color as well as reviewed the essential dos and don'ts of color use in arcade style games.

The Language and Meaning of Color

Color is more than just something we see and experience. It has its own language and can be used to apply specific meanings, moods, and symbolism to the images you create for your games. For example, a black object in a game might be used to signify evil or a background scene that incorporates lots of orange might project a sense of warmth. Along the same lines, certain color choices can provoke specific emotions and feelings in the user. For example, a fast-action arcade shooter rendered in various shades of red might add to the sensation of excitement or an adventure game rendered in cool, dark colors might provoke a sense of fear. By knowing a little something about the "hidden" language and meaning of color, you can maximize its use in your game projects.

Consider the examples in Table 7-1 of popular meanings for some of the more common colors.

TABLE 7-1: Meanings of Common Colors

Color	*Common Meaning(s)*
Red	Danger, urgency, passion, excitement, aggression, heat, love, or blood
Magenta	Imagination or outrageousness
Pink	Friendliness, sweetness, romance, or compassion
Orange	Warning, courage, warmth, or happiness
Yellow	Caution, warmth, brightness, or cowardice
Gold	Illumination or wisdom
Brown	Earthiness or stability
Blue	Attention, dignity, coolness, depression, power, or peace
Turquoise	Refreshing or cool
Purple	Wealth, royalty, mystery, sophistication, or intelligence
Lavender	Romance or fantasy

Color	*Common Meaning(s)*
Green	Safety, nature, health, happiness, environment, envy, or money
Gray	Neutrality, gloom, practicality, or security
Black	Death, evil, rebellion, strength, or fear
Beige	Neutrality
White	Purity, light, or emptiness

NOTE: The examples given in Table 7-1 are general interpretations that pertain mainly to American and Western European cultural sensibilities.

The Cross-Cultural Meaning of Color

Like any other language, color's vocabulary is largely culture dependent. For example, in the Middle East, blue is considered to be a protective color, implying strength; in the west, blue is considered a tranquil color and implies peace. Similarly, green is a sacred color in some cultures and represents greed and wealth in others. It's important to be aware of these distinctions in order to avoid confusing users from different cultures. This is particularly important given the growth of the Internet and how popular arcade games are with players around the world. Even so, these definitions can be helpful in determining how to portray certain characters and objects with color in your games.

Table 7-2 provides some additional examples of the cross-cultural meanings of color.

TABLE 7-2: Cross-cultural Color Meaning Matrix

Color	*Western Europe & USA*	*Japan*	*China*	*Brazil*	*Nigeria*	*Korea*	*Middle East*
Red	Danger, anger, or stop	Danger and anger	Joy and festivity	Anger and hate	Danger	Anger, danger, evil	Danger and evil
Yellow/ Gold	Cowardice, caution, or warmth	Happiness, grace, nobility	Honor and royalty	Money, gold, and wealth	Sunshine and brightness	Wealth	Happiness and prosperity
Green	Sexual arousal, safety, greed, envy, or environment	Future, youth, energy, or forest	Youth and growth	Hope or wealth	Wealth	Nature, peace, or freshness	Fertility and strength

Color	*Western Europe & USA*	*Japan*	*China*	*Brazil*	*Nigeria*	*Korea*	*Middle East*
White	Purity, virtue, goodness	Death and mourning	Mourning and humility	Purity and peace	Purity	Innocence and purity	Purity or mourning
Blue	Machismo, masculinity, calm, authority, or coolness	Villainy or cold	Strength and power	Happiness	Calm and peace	Cool or freshness	Protection
Black	Death and evil	Evil	Evil	Death	Evil	Darkness or evil	Mystery or evil

NOTE: The examples presented in Table 7-2 aren't meant to dictate how you should use color in your games. Rather, they are provided to educate you on how some users (both domestically and abroad) may interpret the colors you've chosen from a cultural standpoint. When designing games that may wind up overseas, it's important to consider the sensibilities of the users that may eventually play them.

Do these differences mean that you'll have to rework your existing game artwork to pass muster in different countries? No, probably not. However, you should be aware of the different cultural interpretations of color so you don't accidentally offend users in different countries or improperly communicate the messages or themes associated with your game.

Color and Mood

When used appropriately, color can strengthen the user's interest and stimulate their involvement with your game. Setting the proper mood through your color choices only helps to reinforce this. While the examples in Table 7-3 are by no means definitive, they do provide you with some good starting points on how to best tailor your color selections for different game audiences and scenarios. For example, you wouldn't want to use lots of warm, bright, "happy" colors for a game with a dark or violent theme. Along the same lines, you wouldn't want to use very strong or aggressive colors for a game with peaceful or harmonious overtones.

By applying these meanings to your graphics, you can induce different moods in users as they play your game. For example, graphics rendered in dark hues such as gray can instill a sense of fear or fright in a scene. Similarly, certain shades of blue can set a melancholy tone while orange can transmit a happy tone.

Please refer to Table 7-3 for some examples of when and where to use certain colors to create specific moods and emotions in your games.

TABLE 7-3: Game Mood Color Usage Matrix

Desired Mood	*Recommended Game Type*	*Suggested Foreground Color Combinations*	*Suggested Background Color Combinations*
Happy, upbeat, cheery	Maze/chase games, puzzlers, platformers, and educational games for young children	Oranges	Reds and yellows
Sadness, gloom, despair	Shooters and platformers	Grays	Blues
Harmony, peace, wisdom	Educational games	White	Blue and gold
Evil, doom, death	Shooters and platformers	Blues	Grays
Mystery, adventure, fantasy	Maze/chase games, puzzlers, platformers, and educational games for young children	Purples	Lavender, magentas, pinks, and gold
Purity, romance, sweetness	Maze/chase games, puzzlers, platformers, and educational games for young children	Pinks	Whites, reds, and lavender
Nature, stability, earthiness	Shooters and platformers	Greens	Grays and browns
Technology, futuristic	Maze/chase games, puzzlers, and platformers	Grays and blues	Purple and gold
Excitement, anger, power	Maze/chase games, puzzlers, and platformers	Reds	Blues and oranges

NOTE: For our purposes, foreground colors refer to the colors used for foreground screen objects such as sprites and bonus/pick-up items. Background colors refer to background tiles, scenes, and framing elements. As indicated in Table 7-3, these color choices are just suggestions. Your individual tastes and the type of game will actually dictate the colors you use. Even so, I thought it might be helpful to give you a sense of how certain colors can project certain moods, feelings, and emotions to the user.

Color Perception Issues

As one might expect, everyone perceives color somewhat differently. In some cases, these differences in perception are due to one's upbringing or cultural environment. However, in most cases, biological and physical factors are responsible for these differences. Of these, age and gender seem to play the most significant roles.

Age and Color Perception

Age can have a major effect on color perception and actually might influence how the user enjoys and experiences your game.

In a nutshell, this is how different age groups interpret color:

- **Young children**—Prefer warm and very intense colors as they instill a sense of happiness.
- **Older children and young adults**—Respond better to bright, warm colors than dull, cool colors.
- **Adults**—Prefer cooler, more subdued colors to warm, saturated colors.
- **Older adults**—Respond better to brighter colors due to degrading eyesight.

Table 7-4 outlines the issues associated with each of these age groups and provides some suggestions on how to accommodate them.

TABLE 7-4: Age Groups and Color Use Suggestions

Age Group	*Suggested Color Choices/Schemes*
Under 10	Use warm and very intense color schemes. They're friendly, cheerful, and non-threatening to younger audiences. Enhances the "cuteness" factor of most games targeted toward young children.
10-25	Use warm and intense color schemes when you need to attract attention. Don't be afraid, however, to use darker or dreary color combinations with this age group if it makes the overall game experience more realistic.
25-50	Limit the amount of warm and intense colors for adults. They're no longer into candy canes and lollipops. They want action and are particularly interested in maintaining the suspension of disbelief (i.e., realism). Feel free to use plenty of cool, dull, intermediate colors for games targeted towards these audiences. For them, realism counts more than anything.
Over 50	As people age, they begin to experience difficulty discerning between different colors. This is especially true for older adults, as they tend to see colors dimmer than they actually are. As a result, use warmer and more saturated colors for games geared towards older audiences.

NOTE: As always, use the information provided in Table 7-4 as suggestions only.

Gender and Color Perception

Surprisingly, game designers and graphic artists seldom take the issue of gender into account. There's evidence that gender plays a significant role in color appreciation and recognition, which in turn may influence how both men and women perceive and enjoy your game.

Simply put, the research of gender-based color perception is interesting, to say the least. Studies have shown that women prefer cooler colors than men do. Similar studies concluded that men tend to prefer brighter, more intense colors than women do. Moreover, women are able to distinguish and perceive color better than men are.

What does this mean in real-world terms? Well, this research suggests several things, including:

- The possibility that women and girls are more likely to play and enjoy games with soft, cool, or pastel color schemes than men.
- The possibility that men and boys are more likely to play and enjoy games with warm, saturated colors than women.
- The possibility that women and girls are probably more sensitive and aware of color schemes used in games that don't quite match reality. For example, they are probably more likely to tell that a game is using the wrong shades of brown for wood or hair, for example, than most men are.
- The possibility that women and girls may be more likely to have their moods altered by a particular color scheme than men.

Table 7-5 summarizes these gender-specific differences. In any case, don't let this issue stop you from making the game you want to make. Rather, just be aware of it and take it into consideration when you plan and select the colors for your next game project.

TABLE 7-5: Gender and Color Preference Summary

Gender	*Warm Colors*	*Cool Colors*	*Saturated Colors*	*Softer Colors*	*Color Sensitivity*
Men	Prefer	Not preferred	Prefer	Not preferred	Low
Women	Not preferred	Prefer	Not preferred	Prefer	High

NOTE: There is no significant evidence that different races perceive colors differently. Instead, age, gender, and culture remain the main determinants of color perception.

Other Important Color Concepts

Before delving further into the other aspects of color use, it's important that you understand some of the lingo and concepts you're likely to encounter throughout the rest of this book, not to mention the software you'll use. Therefore, you should understand such items as:

- Shade
- Tint
- Contrast
- Luminance

Shade

Shades are the dark values of a particular color. Blending a given color with different degrees of black produces shades. Shade plays an extremely important role in arcade game graphics because it gives objects the illusion of realism by simulating how light is reflected and absorbed by different objects. For example, anyone can draw an apple and color it red. However, unless they properly shade it with progressively darker shades of red, it won't look very realistic.

Figure 7-4 demonstrates this concept by showing progressively darker shades of white as you move towards the right.

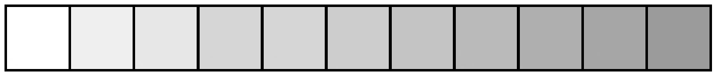


FIGURE 7-4: Example of Shade

Tint

Tints are the light values of a particular color. Essentially, tint is the inverse of shade. Blending a given color with varying degrees of white produces different tints.

Figure 7-5 demonstrates this concept by showing progressively lighter shades of black as you move towards the right.

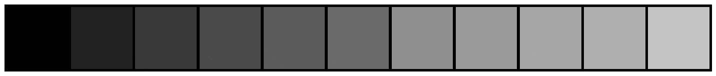


FIGURE 7-5: Example of Tint

Contrast

Contrast emphasizes the differences between two colors. For example, both white and black are contrasting colors, as are many complementary colors. Like shade, contrast is an important element in arcade game design when properly used, as it allows you to create excitement and interest with your images.

Contrast is particularly important for backgrounds because without proper contrast, your foreground objects will be difficult to distinguish against backgrounds of different colors and complexities.

Images that exhibit proper contrast are much more pleasing to the eye than images that don't. Figure 7-6 shows how contrast can influence visual appeal. Notice how much better object A looks when compared to object B. This is because object A uses proper contrast.

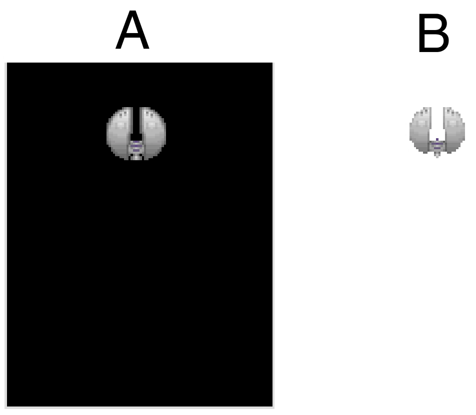


FIGURE 7-6: Example of Contrast

Luminance

Luminance is the energy of a given color. Colors with more luminance will appear brighter than those with less luminance.

Figure 7-7 demonstrates this concept. Notice how object A appears so much brighter than object B. This is because object A has more luminance than object B.

Luminance influences game graphics in various ways. For example, objects with low luminance will be difficult to see against dark backgrounds and vice versa.

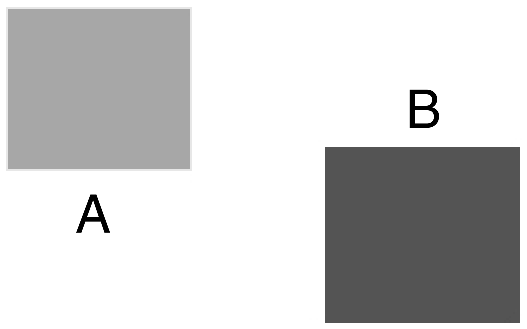


FIGURE 7-7: Luminance Example

Smoothing Objects with Color

In Chapter 2, we discussed how screen resolution could cause unsightly stair stepping (called aliasing) to occur along the edges of graphic shapes as they are drawn on the screen. Well, aside from increasing the available resolution, the only other way to improve the quality of images and reduce the impact of aliasing is to use careful color shading. The most common method to accomplish this task is to use what is called *anti-aliasing*. Anti-aliasing uses a variety of algorithms to blend the edges of an object with shades of a similar color. This has the effect of smoothing the edges of the object and makes it appear more natural against the background. Figure 7-8 demonstrates this concept by comparing two graphic shapes. The object on the left is aliased while the object on the right is anti-aliased. Notice the subtle shades of gray along the edges of the object on the right and how much smoother it appears on-screen.

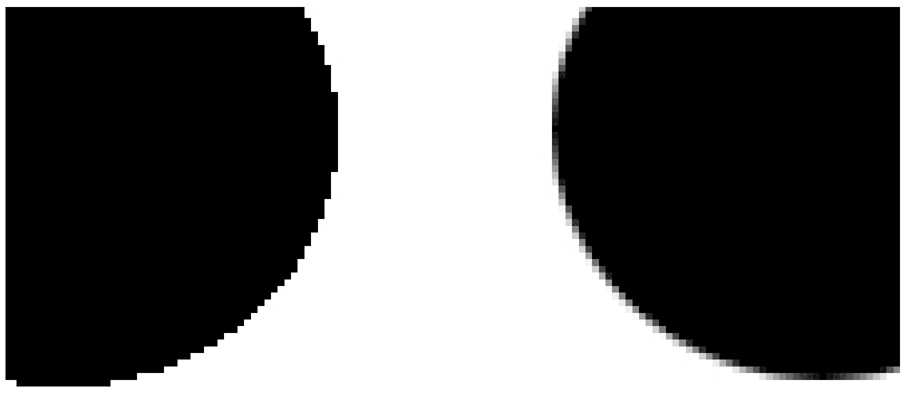


FIGURE 7-8: Aliasing vs. Anti-aliasing

Anti-aliasing is a powerful technique with many, many applications in arcade game graphics. When used properly it can greatly improve the appearance of all of your text and graphic objects. Therefore, you are encouraged to take advantage of it whenever possible.

One thing to understand is that anti-aliasing won't be available to you in every instance. This might be due to a limitation of your graphics program or due to color limitations in the current display mode since there must be extra colors available to produce the smoothing effect. However, you can effectively simulate anti-aliasing by taking advantage of the power of shade and picking similar colors to manually blend an object's edges with the contents of the background.

Volume, Light, and Shadow

Every object has volume, whether it's an airplane, egg, building, or coffee cup. Volume adds the element of depth to objects. In turn, this depth makes objects appear natural and realistic. In order to achieve the illusion of volume in a 2D space, you must understand how to manipulate light to bring out the subtle and dramatic differences exhibited by different objects.

Light is by far the most important element in representing volume. All of the shadows and highlights visible on objects are directly influenced by the origin of the light source that shines on them.

The origin of the light source directly determines the size and location of shadows and highlights cast by a particular object. Shadows are created whenever light is unable to reach certain parts of an object since the object itself blocks it. For example, a building casts a shadow because it blocks all or part of the sun. Highlights, on the other hand, are created whenever light is reflected off an object. For example, a metal dome displays a highlight when light is reflected off its surface.

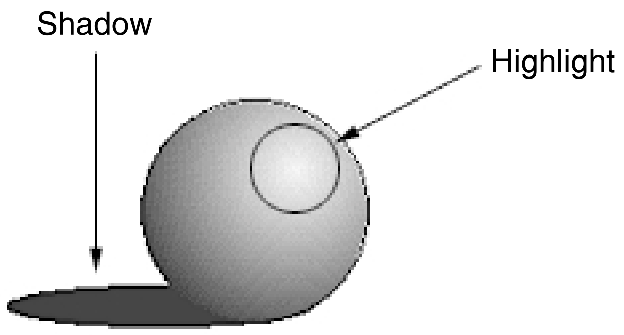


FIGURE 7-9: Shadow and Highlight Example

It's very important to understand that the appearance and positioning of shadows and highlights on objects are not constant. They can change and tend to move along with the light source that created them. Many designers fail to take this factor into account when they design their artwork.

Figure 7-10 shows some examples of this phenomenon.

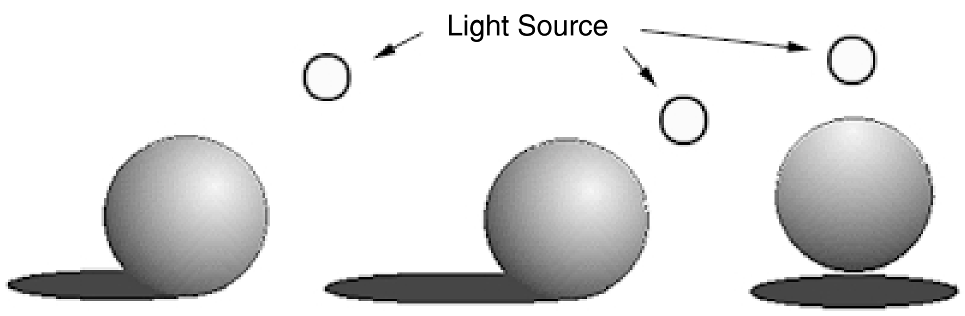


FIGURE 7-10: Light Source Movement and Impact on Shadows and Highlights

Shadows possess an interesting property that highlights do not. Shadows take the general shape of the object that casts them. For example, if the object casting a shadow is round, so is its shadow. The actual size and shape of the shadow will depend, however, on the position of the light source. Light sources that are positioned at extreme angles will cast longer, thinner shadows while light sources that are positioned at slight angles will cast shorter, thicker shadows.

Basic Rules of Light and Shadow

There are several simple rules that you should remember when working with light and shadow. Understanding them will help you to produce convincing shadows and highlights. These rules are:

- All shadows an object casts will always appear darker than any part of the object itself.
- Always select colors that meet the user's contextual expectations. In other words, don't use a dark color to render a highlight! Highlights should be created using very intense colors such as white or yellow but can also be made up of lighter versions of other colors as well. Similarly, shadows should be created using dark colors such as gray or very dark shades of the primary colors.
- Always make sure you properly orient the location of shadows and highlights. For example, a common mistake many designers make is to place shadows and highlights on the same side of an object. This is wrong. Shadows and highlights will always appear away from each other.

- The closer the light source, the brighter the highlight on an object. This means that you should draw the highlight with a larger radius and with more intensity to properly reflect the proximity of the light's reflection.
- Don't use unrelated shades to render shadows! For example, if you opt to create a shadow using shades of gray, stick with it. Don't suddenly introduce blues, reds, or other colors. This will simply ruin the effect.
- Objects with rounded and/or smooth surfaces tend to cast softer, more subtle shadows, i.e., lighter shadows.
- Objects with sharp and/or distinct edges tend to cast harder and more distinct shadows, i.e., darker shadows.
- Shadows and highlights must always be used together. One cannot be present without the other; otherwise, you'll break the rules of light and shadow and ruin the element of realism they can provide.
- The length of a shadow varies depending on the angle of the light source. Steeper angles produce shorter shadows. For example, if light reflects in front or above an object, a short shadow will result. Conversely, slight angles produce relatively long shadows. Be careful, however. If the angle of the light source is too slight, the illusion of depth can be ruined because the resulting shadow will be too long.
- Try to limit how you describe shadows and highlights by using a maximum of four to eight shades of a given color. Using any less reduces the effectiveness of the illusion while using any more is simply overkill.

Table 7-6 contains some examples of good colors to use for shadows and highlights.

TABLE 7-6: Useful Shadow and Highlight Colors

Shadow Colors	*Highlight Color*
Black*	White
Dark gray*	Light gray
Medium gray*	Yellow
Dark blue	Light yellow
Very dark green	See Note
Very dark red	See Note

NOTE: Colors marked with an asterisk (*) denote realistic shadow colors. Other colors can be used to render shadow effects but with diminished realism. Highlight colors work somewhat differently as they always use white or yellow to represent the area where the reflection of light is the most intense.

However, in many instances they can also consist of lighter color variations of the object itself and still remain visually effective.

Accurately Representing Volume with Color

Creating effective renditions of volume require more than accounting for the position of a light source. Rather, objects with volume require the use of color shading and gradients to accurately create a sense of depth. Gradients have been previously described as transitional ranges of color that smoothly fade from one shade to another. Gradients can go from light to dark or dark to light. Gradients play an extremely important role in arcade game graphics as they can be used to make objects appear smoother and more "natural" looking. Once you master their usage, you'll never be guilty of creating flat, lifeless artwork again.

In their most basic form, gradients can be applied to objects in two ways: *linearly* or *radially*. Gradients are typically applied to objects as color fills via your painting software's Fill tool. However, you can also use gradients to manually shade in your objects.

NOTE: Linear and radial gradients are options provided by the Fill tool in many painting programs. Many painting programs also provide additional gradient options such as horizontal and contoured fills; however, they are all basically offshoots of linear and radial gradients as well.

As the name implies, linear gradients are applied using a series of lines. Look at Figure 7-11 for example. It shows how we would use a linear gradient to make an object appear as if it were rounded even though it is clearly flat.

By adjusting the light source, we can continue the illusion as shown in Figure 7-12.

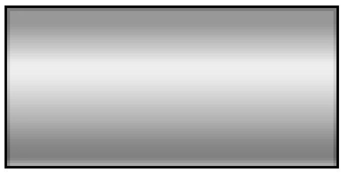


FIGURE 7-11: Linear Gradient with Light Source Directly Above

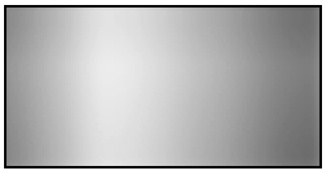


FIGURE 7-12: Linear Gradient with Light Source at Side

Notice the closeness of the colors that appear in the gradient. This subtle shading is crucial, as using colors that are too contrasting or dissimilar to each other will ruin the effect.

Radial gradients are a bit more complex to use than linear gradients. Figure 7-13 demonstrates how one might be applied to an object. Notice that the radial gradient assumes the shape of the object to which it is applied.

By subtly blending and shading the colors present in the gradient, we can also achieve the illusion of smoothness. Should we opt to use a rougher method of shading, we can achieve a grainy, textured look as illustrated by Figure 7-14.

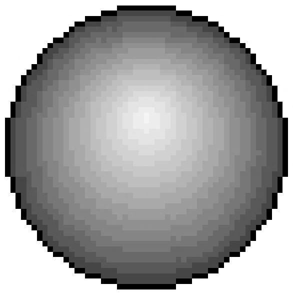


FIGURE 7-13: Radial Gradient

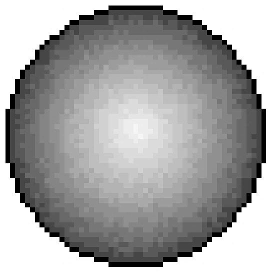


FIGURE 7-14: Rough Radial Gradient

Rules for Gradient Use

Color gradients have simple rules. Follow them and you'll successfully create the illusion of depth and volume in the objects you create. These rules are:

- Always select shades of color with sufficient contrast. Gradients tend to be less effective if the shades between colors are too similar to each other. For example, if you can't visibly discern between two colors in a gradient, chances are that one of the colors is too similar to the other.
- Apply linear gradients to long and narrow objects. Linear gradients don't work well for wide objects, as there are usually not enough shades present in the gradient to cover the entire surface area.
- Apply radial gradients to short and wide objects. They usually don't look right when applied to long and narrow areas due to their circular orientation.
- Avoid using too much distance between the next shade in your gradient when shading in objects. It's been my experience that most objects start looking flat after about eight pixels between gradient colors, except at relatively high screen resolutions. If you're trying to fill in a large area and there aren't enough colors in your gradients to cover the area convincingly, simply add more colors to them.

- Gradients tend to be ineffective on very small objects due to the physical limitations imposed by screen resolution.
- The larger the image, the longer the color gradient should be. Otherwise, the illusion of depth may be jeopardized due to the presence of flat color.
- The longer the color gradient, the smoother the overall shading effect will be.
- The shorter the color gradient, the rougher the overall shading effect will be.
- The smaller and simpler the object is, the shorter the color gradient should be.
- Use smoother radial gradients whenever you have a large number of shades in your gradient. Otherwise, use rougher gradients to maintain the illusion of more color being present in a gradient than there actually are.

It's difficult to recommend specific gradient sizes for a given game project. Therefore, I created Table 7-7 as a guide for determining the proper gradient sizes for use in your artwork.

TABLE 7-7: Color Gradient Shade Selection Guidelines

Gradient Size	*Comments*	*Usage Guidelines*
2 shades	The absolute minimum needed to produce the illusion of depth. Generally not recommended. Avoid whenever possible.	Best when used to color very small objects.
3-6 shades	Sufficient to achieve an acceptable level of depth. How convincing the effect is really depends on the shades or tints selected. There should be sufficient contrast between colors or else the power of the effect is minimized. Using more shades or colors is preferred, so only restrict yourself to such ranges if you must.	Best when used to color small objects and areas.
6-8 shades	Sufficient to achieve an acceptable level of depth. How convincing the effect is really depends on the shades or tints selected. There should be sufficient contrast between colors or else the power of the effect is minimized. Eight shades are usually enough to produce fairly good results. While using more shades or colors is preferred, this number should work well enough for most applications.	Best when used to color small to medium-sized objects and areas.

Gradient Size	*Comments*	*Usage Guidelines*
8-16 shades	Produces a very believable illusion of depth in objects and scenes. As always, you should make sure that sufficient contrast exists between tints or shades. Whenever possible, you should standardize on this gradient size since it makes objects appear very realistic while maximizing the use of available color.	Best when used to color medium-sized objects and areas.
16-32 shades	Produces a very believable illusion of depth in objects and scenes but only moderately better than what is possible with 16 shades. As always, you should make sure that sufficient contrast exists between tints or shades. Be aware that only a few types of objects actually benefit from this size gradient. For example, stone and metals will look more realistic but the effect may be lost on other types of objects.	Best when used to color medium to large objects and areas.
32-64 shades	Produces a very believable illusion of depth in objects and scenes but only moderately better than what is possible with 16 shades. As always, you should make sure that sufficient contrast exists between tints or shades. Such gradients seldom offer much advantage over smaller gradient sizes so it's best to avoid unless you have very specific needs in mind.	Best when used to color large objects and areas.
More than 64 shades	Can be used to create some interesting effects for objects and materials such as metals, plastics, stone, and glass but tends to be overkill for pretty much everything else. Use such gradients sparingly as objects shaded with them to make other objects look flat in comparison.	Best when used to color very large objects and areas.

NOTE: I generally recommend restricting your gradient sizes to 16 shades or less. More than 16 can become difficult to manage. Also, sticking with 16 or fewer shades allows you to use color more efficiently without sacrificing image quality.

While we're still on the topic of gradients, be sure to look at Table 7-8. It contains some examples of when and how to use gradients on different types of game objects to achieve the illusion of depth and realism.

TABLE 7-8: Example Arcade Game Object Gradient Usage

Game Object	*Linear Gradient*	*Radial Gradient*
Planet or globe	No	Yes, use coarse gradient unless object is very small. This will provide a more realistic shading effect. Otherwise, use a smooth gradient.
Stone block	Yes, if the block is rectangular or square.	Yes, if the block is oblong. Use a rough gradient to give block a grainy, weathered look; otherwise, use a smooth gradient.
Steel beam	Yes	No
Spaceship hull	Yes, if hull is long and narrow.	Yes, if hull is short and wide. Always use a smooth gradient for this type of object.
Missile/rocket	Yes	No
Terrain	No	Yes, use a rough gradient to simulate different degrees of texture.

NOTE: The information in this table is only meant to give you ideas. It's by no means a definitive list. With both practice and time, you'll find plenty of other creative ways to use and apply your color gradients.

In short, the interplay of light and shadow is one of the most important concepts to understand if you're interested in making your graphics look as realistic as possible. Once you master it, you'll be on your way to creating some very impressive looking game artwork.

Transparency, Translucency, and Opacity

In game graphics, every object has essentially three states: *transparent*, *translucent*, or *opaque*.

Transparency means that light can pass completely through an object. Objects that are transparent allow objects behind them to show through. For example, if light shines through a pane of glass, the object behind the glass will be visible.

The transparency of an object can vary. That is to say, the amount of light that can pass through an object varies. For example, if an object is fully transparent, you will see whatever is behind it in full detail. However, if the object is only partially transparent, you will only see faint details of the background object, usually with some tint inherited from the foreground object's color.

Partial transparency is also commonly referred to as *translucency*. Translucent means that light can partially pass through an object, yet objects that are translucent allow the colors of objects behind them to show through. For example, if light shines through a sheet of blue cellophane, the object behind the cellophane will be partially visible and inherit the blue tint of the cellophane.

Every object has a different level of transparency. As shown in Table 7-9, crystalline and otherwise clear objects such as water, ice, and glass tend to have the most transparency, while objects that are dense such as stone, earth, and metal tend to have the least.

TABLE 7-9: Examples of Different Object Transparency

Object Type	*Transparency Percentage*	*Estimated Transparency Level*
Clear glass, water, or cellophane	100%	Fully transparent
Clear ice	75%	Translucent
Tinted glass or cellophane	50-75%	Translucent
Fog	0-50%	Translucent
Metal, earth, or stone	0%-fully opaque	Opaque (not transparent)

Transparency and translucency are difficult to achieve in games that use 8-bit (256-color) display modes. Instead, most transparent and translucent effects are produced in 16-bit or 24-bit display modes by using a special technique called *alpha blending*. Alpha blending is a method of simulating transparency and translucency by changing the color of the foreground object's pixels (the source) based on the background object's pixels (the destination). The two color values of both the source and the destination are then blended together using a specified level of transparency. For example, applying transparency to a red block on a white background will produce a shade of light red or pink.

Opacity is the opposite of transparency. Opaque objects will not let light pass through them. For our purposes, opaque objects are solid and retain their original color and shading. You will not be able to see any object placed behind an opaque object like you can with a transparent or translucent object.

By default, all of the objects we draw are assumed to be opaque. Because we will be dealing with a 2D space, transparency will only have a limited value for most of the arcade style game graphics we create. Still, taking transparency into account can produce some interesting effects such as overlaid text and status indicators. Using transparency properly can enhance the realism of your artwork. For example, I can think of several objects that could benefit from employing differing levels of transparency. These include:

- **Waterfalls**—Applying transparency to a waterfall allows on-screen objects to move behind it and still remain visible to the player.
- **Ice**—Applying transparency to ice can make it more realistic and believable.
- **Glass**—Applying transparency to mirrors or windows enables on-screen objects to move behind them and still remain visible to the player.

NOTE: All of these effects can be produced or at least reasonably simulated with your favorite 8-bit painting program. Most of the better ones provide some sort of rudimentary transparency function. However, programs that support 16-bit or 24-bit color display modes are more likely to support realistic transparency effects.

A common transparency effect "hack" employed by arcade games that run in 8-bit display modes is to apply what is known as a *stipple pattern*. Stipple patterns are tightly packed clusters of pixels, usually at 50% density, rendered in a neutral color such as gray. The pattern is then placed over the background in silkscreen fashion. When done correctly, this effect can produce acceptable results. However, it should be pointed out that screen resolution is the most important variable here. The higher the screen resolution, the finer the stipple pattern and, therefore, the better the resulting effect.

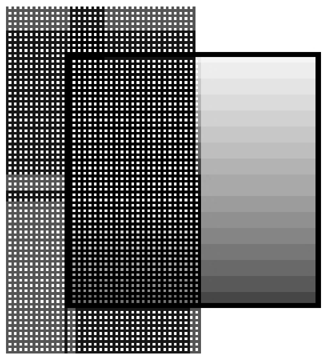


FIGURE 7-15: Simulated Transparency Effect via Stipple Pattern

Bounding Colors

Any general purpose discussion of color use in game graphics design would be remiss if it didn't mention the concept of *bounding colors* or framing colors. As the name implies, bounding colors deal with the application of colors that define boundaries between different colored objects. Bounding colors are essentially colors that outline shapes. They help you to distinguish one object from another as well as help define an object's shape. For example, in a castle scene, bounding colors can be used to give each stone that make up the castle's wall its shape as well as separate it from other stones.

Figure 7-16 illustrates how bounding colors can help distinguish foreground elements from a complex background. In this example, each spaceship in encased in a darker color, which helps give them form and separate them from the rest of the background.

Bounding colors are most effective when you need to separate certain screen elements from each other. This does not mean all elements but rather, only those elements that are at risk for blending in too much into the background and potentially getting lost. To help you determine where and when to use bounding colors, follow the simple rules below.

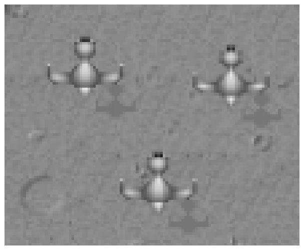


FIGURE 7-16: Bounding Color Example

Bounding Color Rules

- Use bounding colors on objects that move, such as player characters, missiles, bullets, enemies, and spaceships. Because they move, these objects tend to blur into the background and need more definition to bring them to the user's attention than static objects do. Bounding colors will definitely do this.
- Use bounding colors when rendering objects that are improperly shaded. It often takes a while for a beginner to master the correct method of shading objects. Many beginning designers tend to pick colors that vary too little from each other in terms of contrast. As a result, these objects can be hard to see on-screen in certain situations. Using bounding colors to encase these objects will help preserve the object's overall visibility.
- Use bounding colors to give objects shape. Bounding colors serve as a great mechanism for defining the overall look and shape of an object. This is particularly true of objects that tend to be distorted by the limited resolutions support by different display modes.
- Try to restrict bounding colors to a maximum thickness of 1 to 2 pixels around all objects. Any wider and the effect will start to look amateurish, unless, of course, the effect is intentional.
- Always use dark bounding colors against light backgrounds and light bounding colors against dark backgrounds. Table 7-10 contains some examples of useful bounding colors.

TABLE 7-10: Useful Bounding Colors

Bounding Color	*Comments*
Black	A good, general-purpose choice. Particularly well suited for outlining player characters and individual background objects. Can be used regardless of the object's actual color.
Dark blue	Good for bounding water or ice. Objects should be rendered in shades of blue to achieve maximum effect.
Dark brown	Good for bounding wood or earthen objects. Objects should be rendered in shades of brown to achieve maximum effect.

Bounding Color	*Comments*
Dark green	Good for bounding trees, grass, flowers, or jewels. Objects should be rendered in shades of green to achieve maximum effect.
Dark gray	Good for bounding stone, projectiles, beams, or metallic objects. Objects should be rendered in shades of gray to achieve maximum effect.
Dark red	Good for bounding objects such as jewels, bullets, fire, or blood. Objects should be rendered in some shade of red, orange, or yellow to achieve maximum effect.
White	A good, general-purpose color for bounding all sorts of objects against dark backgrounds.
Yellow	A good, general-purpose color for bounding all sorts of objects against dark backgrounds.

NOTE: Which color you actually choose will, of course, depend on the color of the object you're attempting to outline.

Color and Arcade Game Design Styles

Every arcade game has its own unique look or visual design style associated with it. This style determines if the game mirrors fantasy or reality. Color plays a major role in defining the characteristics of each design style and ultimately influences how your game will appear to the player.

Despite the large number of arcade games they all fall into any one of three basic design styles:

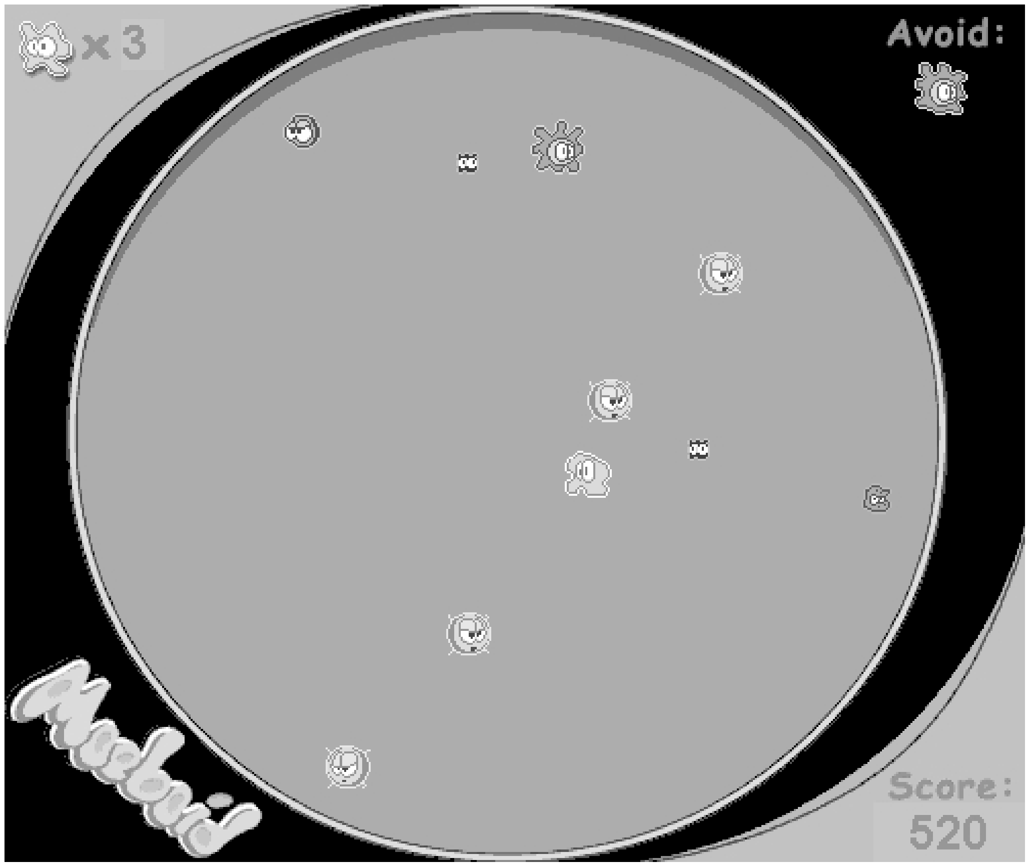
- Cartoon
- Retro
- Realistic

Cartoon

Cartoon-style arcade games tend to mimic the general look and feel of popular television cartoons. Because the graphics in such games contain flat, basic shapes, they often make liberal use of bright and simple colors, such as reds, oranges, and yellows.

They also make considerable use of intermediate colors with lots of shade in order to give objects and scenes the illusion of depth. For example, a cartoon-style dragon character might have bright red polka dots, but its skin could be smoothly shaded with subtle gradients of green.

Figure 7-17 shows what a game that uses cartoon-style artwork looks like. Notice the simple shapes with exaggerated characteristics that are typical of traditional cartoons. This use of color can create games that can be considered charming and even "cute."



Moeboid is a trademark of ZapSpot, Inc. Used with permission.

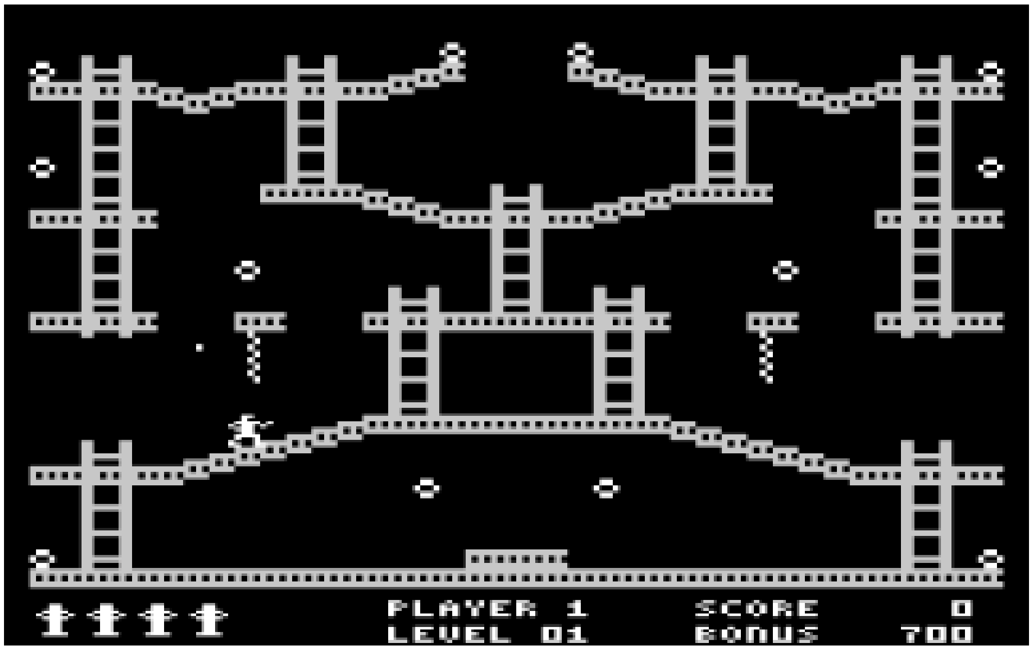
FIGURE 7-17: Cartoon-Style Color Use Example

Retro

Retro, by definition means moving backward. With regard to arcade games, it means giving them an old-fashioned look—something that simulates what computer graphics looked like during the early history of arcade games, i.e., the late 1970s and early 1980s.

Therefore, it's not uncommon for these games to have spartan, minimalist artwork that utilizes simple, blocky shapes. For such artwork, it's best to use flat colors such as medium red, blue, or green as they will help to reinforce the "old school" look you're trying to achieve.

Figure 7-18 illustrates a retro-style game. Notice the crude, blocky, and largely colorless appearance of the artwork. Whether the effect is intentional or not, it definitely gives the game pictured the feel of an earlier period.



Jumpman™

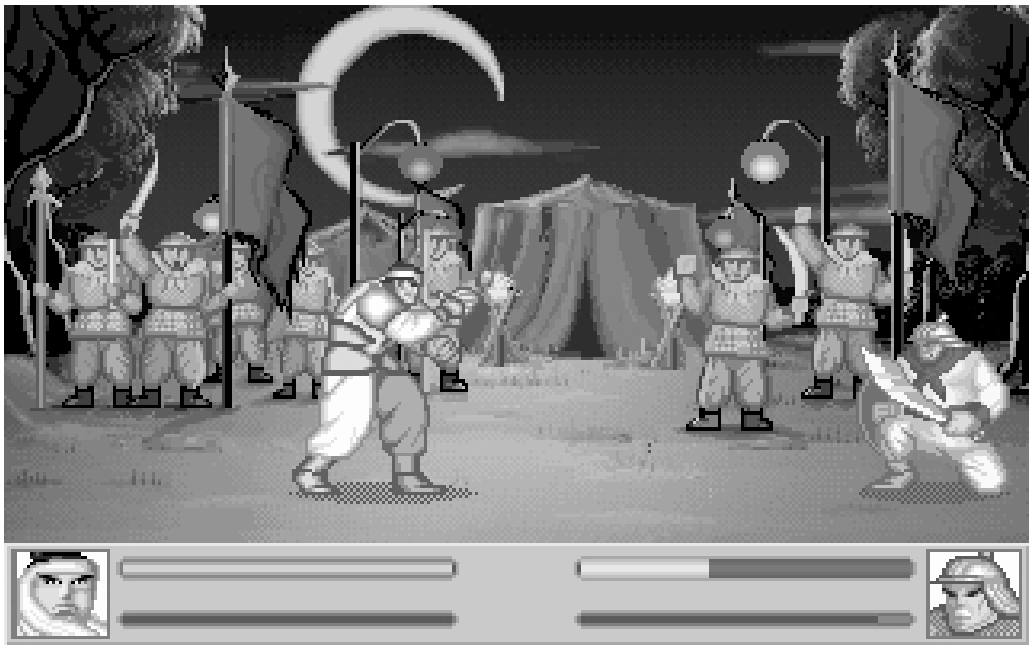
FIGURE 7-18: Retro-Style Color Use Example

Realistic

Maintaining the illusion of realism is one of a game artist's most difficult challenges. Realistic-style arcade games must always use colors that render objects and scenes convincingly without ever altering the user's suspension of disbelief. As long as you use common sense with your color choices, you should never have a problem. For example, you don't want to make tree trunks purple or the sky brown in a sunny nature scene. It simply won't fly with the user.

When designing realistic images, avoid the bright, simple colors used by the cartoon and retro styles and instead go for complex color schemes that mimic nature as closely as possible. This means picking subtle, intermediate shades that have sufficient contrast between them.

Figure 7-19 shows realistic-style game artwork. Although the appearance of the game objects is somewhat exaggerated, color is used to its maximum effect to give the various objects realistic properties from correct shadows to detailed shading. This adherence to realism gives the game pictured the appearance of quality whether or not it's even a good game since we live and see the things around us in a realistic fashion.



Sango Fighter™

FIGURE 7-19: Realistic-Style Color Use Example

Table 7-11 provides some additional comments on using color with different arcade game graphics styles.

TABLE 7-11: Suggested Color Choices and Game Styles

Game Style	*Comments*	*Example Colors*
Cartoon	Using bright and warm colors are fine but don't forget to pick plenty of intermediate shades to give game objects the illusion of depth and a sense that the objects are alive and highly emoted.	Orange, yellow, white, red, magenta, gray, brown, dark blue, green, purple, black.

Game Style	*Comments*	*Example Colors*
Retro	Feel free to use many different combinations of warm and intense colors. The general goal here is to make graphics look bright but flat. Color choices don't necessarily have to mirror reality, i.e., fruits can be purple, but don't go overboard.	Orange, yellow, white, red, magenta, cyan, pink, light green, lavender.
Realistic	Pick only those colors that best match what's available in nature or in everyday life. This means skimp on primary and secondary colors and use intermediate colors and shades as much as possible. This means that leaves should be green but not pastel green, etc. Use discretion and proper judgment; otherwise you'll ruin the overall effect.	Black, white, brown, gray, green, beige, tan.

As you can clearly see, color and how it is applied can have a big influence on the final aesthetics of an arcade game's artwork. Once you understand how color's various properties can affect the style or feel of a game, you'll have a powerful tool at your disposal and the power to create virtually any type of visual illusion in your game projects.

General Rules for Using Color in Arcade Games

There are a number of important rules that you should learn and abide by in order to maximize the impact and effectiveness of using color in your games. For your convenience, I've grouped these rules into two all-encompassing categories: color visibility and usability, and color context and aesthetics. The former looks at those rules that take into consideration an image or object's visibility and how color choice can influence the user experience. The latter examines how to use color both properly and tastefully.

Color Visibility and Usability

- **Always choose colors that have enough contrast between them.** For example, don't place light gray against a medium gray background, as it will be very difficult for the user to distinguish between the two colors. One way to minimize this effect is to use sharply contrasting borders or outline elements to distinguish different objects. The border will act as a visual cue that even though two objects share similar colors, they are in fact different.
- **Always remember that objects will appear brighter on darker backgrounds and darker on lighter backgrounds.** You can achieve some

interesting effects, particularly on background objects, by understanding this phenomenon.

- **As objects get smaller, their colors become less visible and distinct.** When this happens, darker colors, such as blue, become blacker while bright colors, such as yellow, become whiter. Keep this in mind when designing particularly small objects, as certain color details will become lost as a result of this effect.
- **Avoid using very intense or saturated colors over large areas or objects.** While using very intense colors can make objects "pop" on the screen, using such colors over large areas tends to induce eyestrain and fatigue in many users. However, if you must use them, please limit yourself to using them on small objects or localized areas within your artwork. Alternatively, you can use neutral colors for the same areas, as they tend to be kinder on the eyes.
- **Warmer colors will always appear larger on-screen than cooler colors.** For example, objects rendered in red will appear larger than those that are rendered in green. In some cases, this can alter the user's perception of size and break the element of realism that color provides.
- **Don't use shades that offer little difference in intensity.** Such colors tend to be less visible to users and thus less effective. For example, under most lighting conditions, users won't notice the subtle difference between a slightly lighter or darker shade of the same color. Most computer monitors make this effect even worse. Therefore, always make sure that there's a visible and distinct difference between two shades of the same color.
- **Don't use sharply contrasting colors over large, equally sized areas of the screen, i.e., for background or framing elements.** For example, don't use large bands of colors such as red and green. Many users tend to find such combinations annoying over time and users who are annoyed are less likely to play or enjoy your game.
- **Always try to design with a particular color scheme in mind.** The eye automatically recognizes objects that employ similar colors as being related. This makes it easier for the user to navigate around a game screen. For example, if a game uses too many different color schemes, it could potentially disorient the user and make it difficult for them to find out who they are on the screen, etc.
- **Whenever possible, use black or dark blue as your main background color.** This is because objects displayed against these dark colors tend to stand out more, making them easier to see than if placed against a neutral or light-colored background.
- **Understand how a system's gamma level can influence the correct display of color.** For example, you don't want to have the user mistake the shade of brown you selected for a flesh tone as orange. Refer to Chapter 2 for more

information on system gamma differences and what, if anything, you can do about them.

- **Understand how room lighting can influence the display of your color choices.** For example, a color viewed in a room with fluorescent light will appear significantly different from the same color viewed in a room using incandescent light or even sunlight for that matter. As it stands, fluorescent light adds tints of green to color while incandescent light adds tints of red. Unfortunately, much of this is unavoidable since there's no way for you to predict the individual lighting arrangements of every user. However, knowing about what happens can at least allow you to plan some contingencies to minimize this effect.
- **Pure blue should be avoided for small foreground objects.** This is because blue is relatively difficult for the eyes to see. Blue is an excellent choice for backgrounds, however. For example, a dark blue field representing water or the sky makes for a great background in many types of arcade games since most shades of blue exhibit strong contrast.
- **Use warm colors against cool backgrounds and vice versa.** This is because warm colors tend to stand out more against cool backgrounds. For example, a yellow sun will be very noticeable against a sky blue background.

Color Context and Aesthetics

- **Don't use color for color's sake or without a specific plan or color scheme in mind.** The lack of a specific color scheme will show in your designs. Most people do not appreciate haphazard color use because it breaks the illusion of reality that proper color use gives you. After all, you're designing effective arcade graphics and not a Jackson Pollock painting!
- **Use tertiary colors . . . a lot.** Tertiary colors, i.e., natural colors like earthy brown, add more realism to an object. In addition, they tend to translate across cultures better than other types of colors.
- **Don't use too much color in an image.** Believe it or not, using too much color diminishes the realism that color can provide. When you use too much color in an image, it will appear to the user as if you're trying too hard. Color use should appear deliberate but at the same time seem natural. Users will pick up on objects that just don't seem to "look right."
- **Don't forget to take into account the influence that color has over the user's mood and emotions.** Color has the ability to engage and interest users at a level seldom achieved by the other elements of design. Failing to properly use color to affect emotion is simply wasting a major opportunity to further enhance the user experience.
- **Make liberal use of contrasting colors.** Contrasting colors go well together and make graphic objects appear to be more interesting. Feel free to

experiment with different contrasting color combinations but don't go crazy, as too many contrasting colors can ruin an image.

- **Make sure you understand the cultural connotations of the colors you use.** For example, in western societies, black is usually used to depict villains but in some Asian nations, white has the same exact purpose. Refer to Table 7-2 for more examples of cross-cultural interpretations of color.
- **Make sure you understand how age and gender can influence the user's perception of your color choices**. Colors are perceived and interpreted quite differently between genders and age groups. Look at Tables 7-4 and 7-5, respectively for more information.
- **Use color where it belongs and where the user expects it to be.** In other words, don't go against established conventions of color use. For example, avoid using cool colors to render fire and heat or warm colors to render water or ice. This undermines the realism effect that color affords us. It's one thing if you break this rule intentionally, i.e., to simulate the effect of LSD, but it's another to do so accidentally. Most users won't appreciate the deviation from conventional norms.
- **Use complementary colors when you want to create a sense of harmony within an image or between different objects.** Complementary colors go well together and, more importantly, appear that way to the user.
- **Use cooler colors when designing artwork for games that are intended for adults.** Adults seem to respond better to dimmer and cooler colors than do children.
- **Use varied colors as much as possible.** Using too much of one class of color, i.e., warm, cool, intense, or dull, can ruin the impact of your artwork. For example, using colors that are exclusively light or pastel-like can make images seem dull and lifeless. Meanwhile, working entirely in bright primaries can make your artwork look too basic and simplistic. Therefore, try to vary your color use as much as possible.
- **Use very warm and saturated colors when designing artwork for games that are intended for young children.** Children tend to respond better to bolder and brighter colors than do adults. These colors are easy to see and emotionally compatible.

NOTE: These rules are by no means exhaustive nor are they written in stone. They're only meant to serve as guidelines for how to start using color correctly and effectively in your games.

Chapter 8

All About Color Palettes

In this chapter, you'll learn about:

- **Color spaces**
- **Color palettes**
- **Color palette organization**
- **Cross-platform color palette issues**
- **System palettes**
- **Platform specific palette peculiarities**
- **Planning color palettes**
- **Creating color palettes**
- **Color palette effects**
- **Tips for creating effective color palettes**
- **Color reduction**

There are many elements that influence how an arcade game looks. Of these, color selection is one of the most important. Good color selections can make a game stand out aesthetically, make it more interesting, and enhance the overall perception of the game's quality. Conversely, bad color selection has the potential to make an otherwise good game seem unattractive, boring, and of poor quality.

The purpose of this chapter is to show you how to choose and implement color in your games. In addition, it provides tips and issues to consider during this process.

Color Space

As mentioned previously, color is a very subjective entity and is greatly influenced by the elements of light, culture, and psychology. In order to streamline the identification of color, there has to be an accurate and standardized way to specify and describe the perception of color. This is where the concept of *color space* comes in. A color space is a scientific model that allows us to organize colors along a set of axes so they can be easily communicated between various people, cultures, and more importantly for us, machines.

Computers use what is called the RGB (red-green-blue) color space to specify colors on their displays. The RGB color space describes color by exciting the red, green, and blue phosphors present in your computer monitor's CRT.

The RGB color space is usually visualized by using a 3D cube in which each color (i.e., red, green, and blue) is assigned an axis as shown in Figure 8-1.

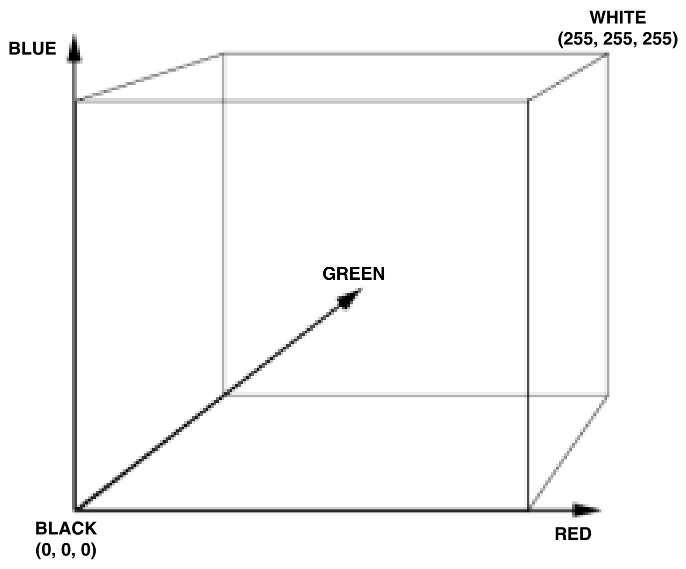


FIGURE 8-1: RGB Color Space

Using this model, three numbers or coordinates are used to identify specific color values. For example, to specify the color black, we would use the coordinates (0,0,0), which effectively means that we are setting all values of the red, green, and blue phosphors to zero. These coordinates are also called *RGB triplets*. A value of zero defines the lowest possible color range of the RGB triplet system but the upper range is actually determined by your computer's graphics hardware.

Every increase to an RGB value indicates one additional level of color brightness. This means, for example, that a computer that has graphics hardware that can support an RGB color range from 0-255 can produce up to 256 unique shades of brightness for a given hue.

HSV, or hue-saturation-value, is another type of computer color space. Under the HSV system, hues are specified using a color wheel as shown in Figure 8-2. The colors on the color wheel are separated by degrees (0 -360). Here, 60 = Yellow/Orange, 120 = Green, 180 = Light Blue/Cyan, 240 = Dark Blue, 300 = Magenta/Purple, and 0 = Red. Meanwhile, saturation is specified using a percentage scale (0-100%) where 0% is a gray value and 100% is full intensity. Value or color brightness is also specified using percentage scales, except in this case 0% represents black and 100% represents white.

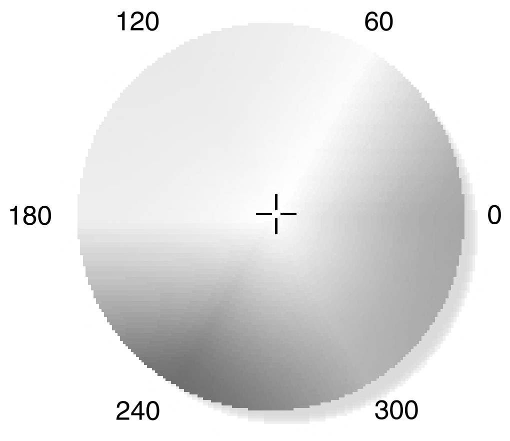


FIGURE 8-2: HSV Color Space

In case you are interested, there are other computer-based color spaces. These include:

- HSL, *Hue Saturation and Lightness*
- HSI, *Hue Saturation and Intensity*
- HSB, *Hue Saturation and Brightness*

NOTE: Most graphics programs allow you to specify colors using one or more of these color space systems. However, because the RGB scheme is the most common, all colors are specified using RGB values in this book.

Color Palettes

A color palette represents the maximum number of colors that can be produced by using all three combinations of red, green, and blue available in the RGB color space. As mentioned in Chapter 2, color palettes come in two flavors, *physical* and *logical*.

Physical palettes contain all of the colors supported by the system's graphics hardware, while logical palettes contain only a fraction of the colors that are available in the physical palette.

When we design game graphics, we select colors from the system's physical color palette but actually render objects using the colors present in the logical palette. Figure 8-3 illustrates the relationship between the two.

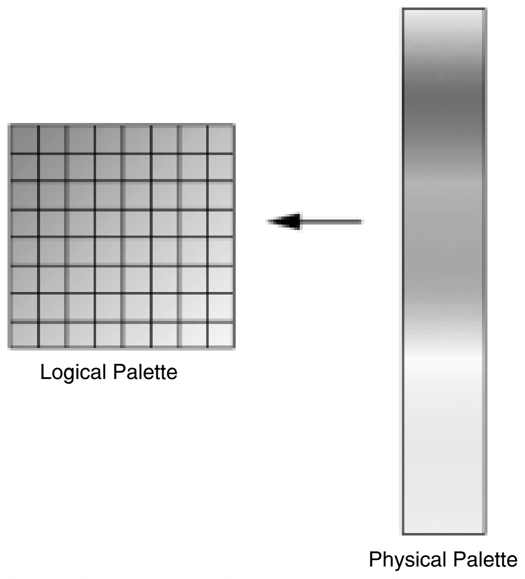


FIGURE 8-3: Physical vs. Logical Color Palette

NOTE: For all intents and purposes, the term *color palette* is really synonymous with a logical palette. Therefore, to make future references more consistent, the term color palette will be used whenever a reference is made to a logical palette for the remainder of the book.

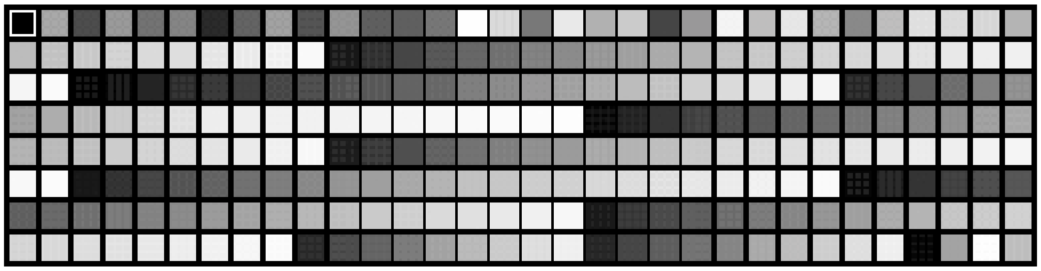


FIGURE 8-4: Color Palette Example

Color palettes are best thought of as "windows" into a larger world of color. Much like a painter's palette, they are essentially containers that hold the colors with which we paint and draw objects on the screen. In order to make the lives of developers easier, color palettes were developed as a means of managing and specifying small groups of colors within the hardware color space.

As you might expect, color palettes come in different sizes. Larger color palettes can hold more colors and in turn allow graphic objects to be rendered with more color fidelity. Meanwhile, smaller color palettes hold fewer colors and place restrictions on the amount of colors that a given image can contain.

The actual size of a color palette is always determined by the hardware capabilities of the system. However, it's unusual to find color palettes with more than 256 colors in them since color management quickly becomes unwieldy.

Because they are so convenient for managing and specifying colors, color palettes are ideally suited for all types of arcade graphics development. This stems from the fact that they offer game developers a number of distinct advantages, including:

- **Universal compatibility with all display modes**—Color palettes, especially those that use 16 or 256 colors, are a common denominator among all display modes. For example, images that use 16 or 256 colors are guaranteed to display properly even when shown on display modes that use thousands or even millions of colors. However, the same is not true the other way around.
- **High degree of compression**—Images that use color palettes with small amounts of color (i.e., less than 256) tend to require much less disk space than those that contain thousands or millions of colors.
- **Cross-platform compatibility**—In this day and age, it can be assumed that virtually all platforms can display images with 16 or 256 colors in them. This makes it relatively easy to port palette-based artwork between different hardware platforms. The same can't be said for images that were created in display modes that support thousands or millions of colors as these display modes are typically only found on higher-end computers manufactured in the last two or three years.

- **Ease of manipulation**—Color palettes are relatively easy to manage and manipulate from both a creative and technical perspective. This isn't true for display modes that use thousands or millions of colors, since direct color access in these modes tends to be much more cumbersome.
- **Good color rendition**—Color palettes can provide a sufficient level of color fidelity for most arcade style games. This makes them useful for rendering most types of objects and images that are often featured in these types of games.
- **Support for special effects**—Color palettes can support powerful special effects such as color cycling and color fades. These effects aren't easily achieved in display modes with thousands or millions of colors without special programming tricks.

NOTE: All of the programs described in Chapter 6 provide the ability to easily manipulate color palettes.

Table 8-1 outlines some common color palette sizes supported by different computer platforms:

TABLE 8-1: Color Palette Sizes by Platform

Platform	*Color Palette Size*	*Comments*
DOS	16 or 256	The actual display mode determines the number of available colors in the color palette. Sixteen colors are typically used in older EGA and MCGA display modes. Although these display modes are backward compatible with most modern graphics cards, very few games are written specifically for 16 colors anymore. Virtually all DOS games created since 1991 are written for display modes capable of displaying 256 colors in their color palette.
Linux	16 or 256	The actual display mode determines the number of available colors in the color palette. Sixteen colors are typically used in older VGA display modes. Sixteen colors are usually the minimum requirement under the various Linux desktop managers. Most Linux-based games use 256 colors or more.
Macintosh	256	Sixteen-color palettes were quite common on color Macintosh systems until the advent of the PowerMac series in 1994. At that time, game developers were encouraged to use the 256-color palette and the 16-color palette was deprecated.

Platform	*Color Palette Size*	*Comments*
Windows 3.1, 95, 98, NT 4.0, and 2000	16 or 256	The actual display mode determines the number of available colors in the color palette. Sixteen colors are typically used in older VGA display modes. Although these display modes are backward compatible with most modern graphics cards, very few games are written for them anymore. Virtually all Windows games since 1994 are written for display modes capable of displaying 256 colors in their color palette.

NOTE: You may be wondering why there have been no references made to color palettes with thousands or millions of colors in them. Well, they weren't mentioned because these display modes do not actually support color palettes. Rather, they have access to the entire physical palette. On the other hand, color palettes only have access to a relatively small selection of the colors available within the entire physical palette.

NOTE: Support for 16-color palettes has pretty much disappeared on all platforms, and both market forces and the development community at large have long discouraged development of games that use them. Therefore, they aren't covered in this book. Instead, if you design arcade games, it's strongly recommended that you only use 256-color palettes.

Color Palette Organization

To better facilitate the selection of colors, color palettes are organized as an array of *palette entries* or *color indexes.* These are markers that indicate the current position of a particular color within the palette along with its RGB color values.

Figure 8-5 illustrates this concept by showing how a color palette with eight colors might be organized.

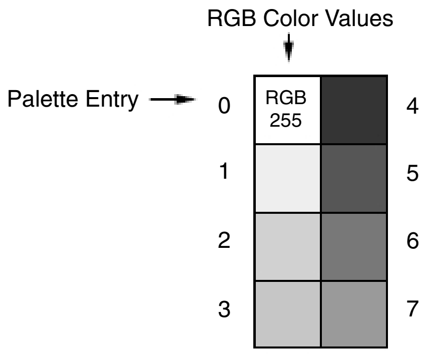


FIGURE 8-5: Color Palette Organization Example

NOTE: Palette entries are always specified starting at 0 and ending at the upper limit of the current palette size. So, for example, if a palette had 256 palette entries, its upper limit would be 255 and its palette entries would be numbered from 0 to 255.

NOTE: Programmers and programming literature often refer to palette entries as *palette registers* or *color registers*. These are just fancier names for the same thing.

It is very important that you understand how color palettes are organized because both graphics programs and programming tools specify individual colors this way. In addition, arrangement also determines the *palette order*, or the particular location of a given color within the palette. Both graphics programs and games come to rely on the palette order in order to determine where certain colors appear and display on the screen.

Although you can usually place colors using any order within a palette, relying on a specific palette order can influence how certain colors appear within an image. For example, if you create an image with the color black in it and then later change the position of black within the palette, all of the objects that should be black will immediately assume some other color value. As you can appreciate, such changes can change the whole character of your artwork.

To better illustrate this concept, consider the color palettes shown in Figure 8-6. Even though color palettes A and B both contain identical color values, they are not the same because their palette order is different. Thus, images that use these colors will look different from each other when displayed using either palette.

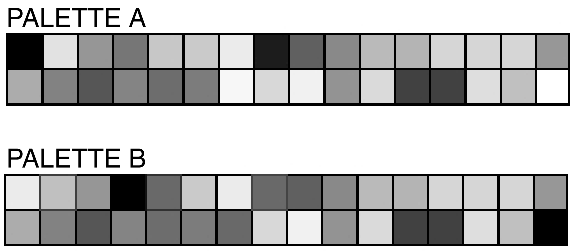


FIGURE 8-6: Color Palette Order

Cross-Platform Color Palette Issues

Each computer platform has its own quirks and peculiarities when it comes to how it supports and implements color palettes. These idiosyncrasies are due to differences in memory architecture and graphics hardware. Of these, one of the prime culprits is the implementation of the DAC chip. All modern computer graphics hardware uses a special chip called a *DAC*, or digital-to-analog converter, to generate the wide range of color supported by the RGB color space. On older, VGA-equipped systems the DAC circuitry is limited to supporting six bits, or 64 levels, of RGB color intensity. This scheme yields 262,144 possible colors (64x64x64) or 64 variations of red, green, and blue. On newer, SVGA-compatible systems, the DAC circuitry is capable of generating eight bits, or 256 levels, of color intensity. This scheme yields 16,777,216 possible colors (256x256x256).

Please refer to Table 8-2 for more information on the maximum RGB triplet ranges supported by various computer platforms.

TABLE 8-2: RGB Color Value Range Comparisons

RGB Color Ranges	*Maximum Possible Colors*	*Platforms Supported*	*Comments*

R = 0-1
G = 0-1
B = 0-1
	16	Computers that used CGA-compatible hardware typically used this color range.	Obsolete.
			The CGA color palette had two states: normal and intense. Half of its palette was simply a higher intensity version of the original color.

R = 0-3
G = 0-3
B = 0-3
	64	This color range was typically found on computers that used EGA (Enhanced Graphics Adapter) graphic modes (circa 1984). Some early 16-bit arcade game consoles were also limited to this color range.	Seldom used
			It's interesting to note that EGA-compatible display modes were quite common for DOS-based arcade games up until about 1993.
			The EGA hardware palette contains only very bright or very dark colors as its DAC chip was incapable of producing subtle shades of the same color.

R = 0-5
G = 0-5
B = 0-5
	216	Macintosh, Windows, Linux, and Java	Used extensively by Web browsers to render a cross-platform color palette of 216 colors common between the various versions of Windows, Linux, and the Macintosh.

R = 0-7
G = 0-7
B = 0-7
	512	The Atari ST line of computers (circa 1985)	Seldom used

R = 0-15
G = 0-15
B = 0-15
	4,096	The Commodore Amiga line (circa 1986) and the Apple IIgs series (circa 1986). Some early color laptop PCs and the later Atari STe/TT computer models also used it.	Seldom used

R = 0-31
G = 0-31
B = 0-31
	32,768	Some 16- and 32-bit video game systems occasionally used this color range.	Seldom used

RGB Color Ranges	*Maximum Possible Colors*	*Platforms Supported*	*Comments*

R = 0-63
G = 0-63
B = 0-63
	262,144	DOS systems that use MCGA and VGA display hardware.
		Older versions of Windows using VGA hardware.
		The lamented Atari Falcon 030 multimedia PC also used this color range.
			Very common but rapidly becoming obsolete.
			All VGA-compatible graphics cards use this color range since the technology was introduced in 1987. Virtually all games that run under DOS are limited to this color range as DOS has trouble "seeing" larger RGB color spaces without special software.

R = 0-255
G = 0-255
B = 0-255
	16,777,216	DOS with SVGA video hardware, Linux, the Macintosh, and all versions of Windows.	Very common and the current industry standard.
			The first popular computer to use this color range was the Macintosh II of 1987 vintage. Since that time it has become standard for all Macintosh models. However, it didn't start becoming common on PCs until the introduction of SVGA-compatible graphics boards and Windows 3.1 in 1992.
			It can be safely assumed that all PCs shipped since 1996 can support this color range.

The RGB color ranges supported by both VGA- and SVGA-compatible systems differ from each other only in terms of the color intensities they support. For example, an image created on a system that only supports 64 shades per color will appear slightly darker on a system that supports 256 shades per color. However, the basic color integrity will stay the same, i.e., brown still is brown regardless of whether the color was produced on a system using a 6-bit DAC or an 8-bit DAC.

To compensate for this effect, most graphics software automatically converts the color intensity levels of an image to suit the color capabilities of the currently active graphics chipset.

NOTE: Because of this fact, colors will be specified using a 0-255 RGB color range.

It's interesting to point out that Windows, Macintosh, and Linux systems internally support the 8-bit DAC range, whether SVGA hardware is available or not.

Table 8-3 shows these differences in RGB color ranges between the most common computer platforms:

TABLE 8-3: RGB Color Value Range Compatibility by Platform

Platform	*RGB Color Range*	*Supported DAC Resolution*	*Maximum Possible Colors*

DOS*	R = 0-63
	G = 0-63
	B = 0-63
	
	R = 0-255
	G = 0-255
	B = 0-255
		6 bits or 8 bits*	262,144 or 16,777,216*

Java	R = 0-255
	G = 0-255
	B = 0-255
		8 bits	16,777,216

Linux+	R = 0-63+
	G = 0-63
	B = 0-63
	
	R = 0-255
	G = 0-255
	B = 0-255
		6 bits or 8 bits+	262,144 or 16,777,216+

Macintosh	R = 0-255
	G = 0-255
	B = 0-255
		8 bits	16,777,216

Windows 3.1/95/98/NT/2000.	R = 0-255
	G = 0-255
	B = 0-255
		8 bits	16,777,216

* Denotes that DOS can support 8-bit DAC values if SVGA hardware and the appropriate driver software are present.

+ Denotes that Linux and X Windows can support 6-bit DAC values if running on VGA-compatible hardware.

NOTE: Virtually all systems specify these color ranges starting at zero rather than one. Please remember this, as it'll come in handy when you start creating and editing your own color palettes.

NOTE: All versions of Windows will dither any colors that can't be properly reproduced in the current display mode. For example, this occurs when you're specifying RGB values within the 0-255 color range on older hardware that's only capable of RGB color ranges of 0-63.

Even with all of this color capability, the average person cannot discern all of the possible colors contained within the RGB space or physical color palette. So, while it's theoretically possible for some platforms to support as many as 16.7 million different RGB values, the likelihood of the average person being able to distinguish between shade 14,056,922 and shade 14,056,923 is practically nil.

System Palettes

All computer platforms in common use have predefined 16- and 256-color palettes. These palettes are better known as *system palettes*. A system palette is the default color scheme that is activated whenever you first turn on or reboot a computer.

Overall, the system palettes across the different computer platforms tend to share much of the same color choices and arrangements. In addition, they all seem to use similar collections of complementary colors. This section describes the implementation of system palettes across the major computer platforms.

DOS System Palette

DOS doesn't have its own system palette per se; rather, it just uses the default color definitions found in the VGA and SVGA hardware's BIOS (basic input/output system) ROM.

The developers who selected and programmed the colors used in the VGA/SVGA palette may have been good engineers but they were definitely lousy designers. By and large, the VGA/SVGA system palette is totally useless for doing any serious graphics work. Here's a synopsis of why:

- One hundred and fifty-two of the 256 colors present in the VGA/SVGA palette lack significant intensity. They are all dark or dim shades and lack sufficient contrast to use them to shade in most types of objects.
- Seventy-two of the 256 colors present in the VGA/SVGA palette are merely rehashes of primary and secondary colors. None of them are particularly good color choices and few have any practical application in arcade game graphics design.
- With the exception of the first 32 palette entries, which do provide some useful shades of gray, there's not sufficient utility or variation in the colors provided.

- All but the first 16 palette entries have color ranges that are too small to produce accurate shading and gradient effects needed to properly render most game objects.

As you can probably gather, the color palette definitions of the DOS system palette are largely unsuitable for serious game graphics work. Therefore, it is strongly recommended that you always take the time to redefine the color palette when working under DOS for game projects.

NOTE: If you're interested in seeing the RGB values for these palettes, they can be found on the book's accompanying CD-ROM under the `PALETTES` directory in the files labeled `DOS16.PAL` and `DOS256.PAL`. These files are in the Microsoft .PAL format and are compatible with *Paintshop Pro* and other programs.

Windows System Palette

All versions of Windows from version 3.1 through Windows 2000 share a common system palette. This palette appears the same regardless of the particular graphics hardware that is installed on the machine on which Windows is running.

NOTE: The Windows 256-color system palette is only available on SVGA hardware as the standard. The VGA hardware specification only provides 16 colors at the 640x480 screen resolution required by Windows. However, for all purposes, the Windows 16-color palette is identical to the DOS 16-color system palette.

Like the DOS 256-color system palette, the Windows 256-color system palette is also poorly designed and it's useful mainly for coloring icons and other GUI screen elements. Here are some of the problems that have been found with it:

- There aren't enough shades of gray present in the palette to realistically depict stone or metallic elements.
- There are too many saturated shades of primary colors (i.e., red, green, and blue) and not enough intermediate or tertiary colors provided. This effectively limits the types of objects this palette can convincingly render.
- The color ranges provided are too small to produce accurate shading and gradient effects.
- Related colors aren't arranged in an accessible order within the palette. This makes the palette very difficult to use in actual projects.

Due to these limitations, I strongly recommend not using the Windows 256-color system palette in your game artwork. It's simply too limiting and restrictive for creating serious game artwork.

NOTE: The only exception to this might be when you're creating artwork or icons for a Windows game that needs to be backward compatible with Windows running on VGA hardware (i.e., 16 colors). In this situation, you must limit yourself to the first 16 palette entries of the Windows 256-color system palette.

NOTE: If you're interested in seeing the RGB values for this palette, they can be found on the book's accompanying CD-ROM under the `PALETTES` directory in the file labeled `WIN256.PAL`.

Linux System Palette

Unlike the other platforms mentioned here, Linux doesn't have an official system palette; rather, it uses whatever color definitions users have defined under their particular desktop manager.

Macintosh System Palette

The Macintosh system palette is interesting in that it shares many of the properties and color arrangements of both the VGA/SVGA (DOS) and Windows 256-color system palettes. Every Macintosh system released since 1990 supports this palette when using an 8-bit color display mode.

Because it shares so much in common with the other system palettes described here, the Macintosh system palette also shares many of the same limitations. Here's a list of them:

- There are too many saturated shades of primary colors (i.e., red, green, and blue) and not enough intermediate or tertiary colors. This effectively limits the types of objects this palette can convincingly render.
- With the exception of the 16 grays in the palette, the Macintosh system palette doesn't provide color ranges large enough to produce realistic-looking shading and gradients.
- Related colors aren't arranged in an easily accessible order within the palette. This makes the palette inconvenient to use in an actual project.
- The Macintosh system palette positions and arranges its colors very differently from how Windows does. This means you won't be able to easily convert images between these palettes without using an image viewer/converter program that supports color remapping.

Again, because of these limitations, I recommend not using the Macintosh system palette for your game artwork. You'll get much better results with a custom color.

NOTE: If you're interested in seeing the RGB values for this palette, they can be found on the book's accompanying CD-ROM under the `PALETTES` directory in the file labeled `MAC256.PAL`.

Java System Palette

As a cross-platform development environment, Java-based arcade games need to display their graphics consistently as much as they have to play consistently on different systems. To facilitate this, Java uses what is called the non-dithering 216-color palette, which is commonly referred to as the Netscape palette.

This palette contains a set of colors that won't dither when displayed inside a browser window regardless of whether it's running on a Macintosh or Windows machine. This fact alone makes this palette useful for cross-platform game projects whether they're written in Java or another development tool.

The Java system palette also borrows many color definitions from other system palettes, namely those from Windows and the Macintosh. Therefore, it too suffers from many of the same issues, including:

- There are too many saturated shades of primary colors (i.e., red, green, and blue) and not enough intermediate or tertiary colors. This effectively limits the type of objects this palette can convincingly render. However, at the same time, these bright colors are actually quite useful in some instances, particularly for creating simple, flat artwork that is commonly seen in many retro-style arcade games, such as *Donkey Kong* or *Bubble Bobble*.
- There are only six shades of any one color. This isn't enough to produce the realistic-looking shading and gradients required by hyper-realistic artwork.
- Related colors aren't arranged in an accessible order within the palette. This makes the palette inconvenient to use in an actual project.

NOTE: If you're interested in seeing the RGB values for this palette, they can be found on the book's accompanying CD-ROM under the `PALETTES` directory in the file labeled `NETSCAPE216.PAL`.

NOTE: Despite its shortcomings, we frequently use the Java/Netscape palette when creating the artwork and animation for ZapSpot's games due to the palettes' special, cross-platform color properties. Examples of where the palette really shines can be found in the games *BullyFrog*™ and *FenceOut*™.

Generally speaking, games that use system palettes tend to look sloppy and unprofessional. Using these palettes might have been acceptable during the 1980s but certainly not anymore. With the color capabilities of today's computers, there is simply no excuse not to take advantage of a custom color palette unless you have a very specialized need, such as developing cross-platform or online games. Game developers who don't take full advantage of custom color palettes are just being lazy.

Platform-Specific Palette Peculiarities

This section describes system-specific issues with using color palettes on different computer platforms.

DOS

Table 8-4 shows the various color palettes supported under DOS-based systems.

TABLE 8-4: Color Palettes Supported under DOS

Display Mode	*Color Palette Size*	*Video Hardware Standard(s)*	*Comments*
320x200	4	CGA, EGA, MCGA, VGA, SVGA	Obsolete. Retained only for backward compatibility with ancient game and graphics software. No longer has any use in arcade game graphics.
320x200	16	EGA, MCGA, VGA, SVGA	Seldom used anymore but was once quite popular with developers such as Id and Apogee during the late 1980s and early 1990s. Has only limited use in arcade game graphics.
320x200	256	MCGA, VGA, SVGA	Supported by all arcade games since the late 1980s. Commonly used and popular with game developers. Has limited use in arcade game graphics when compared to Mode X.

Display Mode	*Color Palette Size*	*Video Hardware Standard(s)*	*Comments*
320x240 (Mode X)	256	MCGA, VGA, SVGA	Software modification of the standard 320x200 MCGA/VGA mode. Commonly used and very popular with game developers. Has significant application in arcade game graphics.
640x200	2	CGA, EGA, MCGA, VGA, SVGA	Obsolete. No longer has any use in arcade game graphics.
640x200	16	EGA, MCGA, VGA, SVGA	Obsolete. No longer has any use in arcade game graphics.
640x350	16	EGA, MCGA, VGA, SVGA	Obsolete. Used in some shareware arcade games during the early 1990s. No longer has any use in arcade game graphics.
640x480	2	MCGA, VGA, SVGA	Obsolete. No longer has any use in arcade game graphics.
640x480	16	VGA, SVGA	Obsolete. No longer has any use in arcade game graphics.
640x480	256	SVGA	Commonly used and popular with game developers. Has significant application in arcade game graphics. Usually requires a third-party VESA driver to access.
800x600	16	SVGA	Not commonly used and only has limited use in arcade game graphics.
800x600	256	SVGA	Not commonly used and only has limited application in arcade game graphics. Usually requires a third-party VESA driver to access.

Palette management under DOS is very liberal. As it happens, DOS isn't restricted to any particular palette order so every one of the 256 color palette entries supported by VGA and SVGA display modes can be redefined. There is one small catch, however: DOS needs to reserve one of the first 16 colors in the color palette so it can display system text. Therefore, if you redefine or blank out any of these colors, you could potentially render the system font invisible. While there's certainly nothing preventing you from doing this, please bear in mind that it may cause difficulties with some programming tools and environments. Otherwise, enjoy the freedom DOS provides when it comes to redefining the color palette.

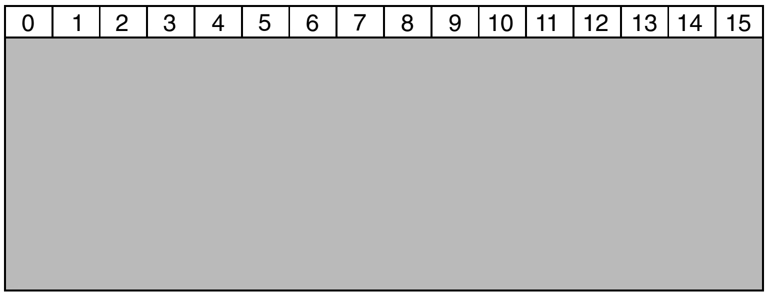


FIGURE 8-7: Diagram of DOS Reserved Colors

Windows

Table 8-5 shows the various color palettes supported under Windows-based systems.

TABLE 8-5: Color Palettes Supported under Windows

Display Mode	*Color Palette Size*	*Video Hardware Standard(s)*	*Comments*
320x240	256	VGA, SVGA	Software modification of MCGA/VGA 320x240 display mode supported by DirectX API. Not supported by Windows 3.1.
640x480	16	VGA, SVGA	Obsolete. Has no use in arcade game graphics, although it was commonly used by many Windows games until about 1994.
640x480	256	SVGA	The standard Windows display mode. Commonly used and very popular with game developers. Has significant application in arcade game graphics.
800x600	16	SVGA	Not very commonly used.

Display Mode	*Color Palette Size*	*Video Hardware Standard(s)*	*Comments*
800x600	256	SVGA	A standard Windows display mode. Not as popular as 640x480 with game developers but starting to become much more common in games.

All versions of Microsoft Windows reserve 20 palette entries for various system purposes such as coloring icons, dialog boxes, and the mouse pointer. Therefore, you shouldn't redefine these colors.

Because of this, only 236 of 256 colors available in the palette can be user-defined. To further complicate matters, Windows does not reserve these colors in one contiguous block; rather, it reserves the first 10 palette entries (entries 0-9) and the last 10 palette entries (entries 246-255) for its own use.

Sixteen of these "reserved" colors are actually composed of standard VGA 16-color palette colors while the remaining four colors are those found in the SVGA 256-color palette. Figure 8-8 shows the organization of the so-called "off-limit" colors under Windows.

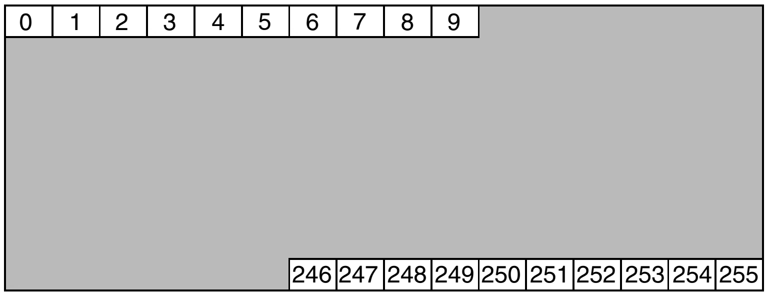


FIGURE 8-8: Diagram of Windows Reserved Colors

TABLE 8-6: Windows Reserved Colors

Palette Entry	*Red Value*	*Green Value*	*Blue Value*	*Color Name*
0	0	0	0	Black
1	128	0	0	Dark red
2	0	128	0	Dark green
3	128	128	0	Brown
4	0	0	128	Dark blue
5	128	0	128	Dark magenta
6	0	128	128	Dark cyan

Palette Entry	*Red Value*	*Green Value*	*Blue Value*	*Color Name*
7	192	192	192	Light gray
8	192	220	192	Light green
9	166	202	240	Light blue
246	255	251	240	Off-white
247	160	160	164	Medium gray
248	128	128	128	Dark gray
249	255	0	0	Light red
250	0	255	0	Light green
251	255	255	0	Yellow
252	0	0	255	Bright blue
253	255	0	255	Magenta
254	0	255	255	Cyan
255	255	255	255	White

NOTE: Occasionally some Windows video drivers will redefine some of the values presented here. However, the RGB values shown here tend to be the most common implementation by various Windows video card drivers.

NOTE: This restriction only exists in 8-bit color display modes. The 15-, 16- and 24-bit color display modes don't experience this problem.

Unfortunately, this situation leaves Windows game developers with fewer available color choices than the DOS, Linux, or Macintosh platforms provide. Therefore, you'll need to plan your color palettes even more carefully under Windows than on any other system. Not only will you have to make do with fewer colors but also you'll have to take care with regard to how they are arranged.

Linux

Table 8-7 shows the various color palettes supported under Linux-based systems.

TABLE 8-7: Color Palettes Supported under Linux

Display Mode	*Color Palette Size*	*Video Hardware Standard(s)*	*Comments*
640x480	16	VGA, SVGA	The default and minimum video mode for X Windows. Only has limited use in arcade game graphics.

Display Mode	*Color Palette Size*	*Video Hardware Standard(s)*	*Comments*
640x480	256	SVGA, Macintosh*	The standard Linux display mode. Commonly used and very popular with game developers. Has significant application in arcade game graphics.
800x600	16	VGA, SVGA	The minimum display mode for systems running in an 800x600 resolution.
800x600	256	SVGA, Macintosh*	A standard Linux display mode. Not as popular as 640x480 with game developers but starting to become increasingly common in games.

* Denotes that Linux can also run on Macintosh hardware.

Most implementations of Linux use a version of the X Windows desktop interface. In an 8-bit display mode, X Windows employs a color reservation system that allows applications, particularly arcade games and graphics packages, to grab as many colors as they need. In order to compensate for this and keep the display legible, X Windows only reserves the first two palette entries, black and white, for system purposes.

Table 8-8 shows their RGB values. These reserved colors include the first and last palette entries. All 254 of the remaining colors are completely user definable. This allows 256-color DOS, Windows, and Macintosh images to be easily ported over to the Linux platform. However, full, 256-color Linux images won't port easily to the Windows platform without a bit of reworking and/or color loss.

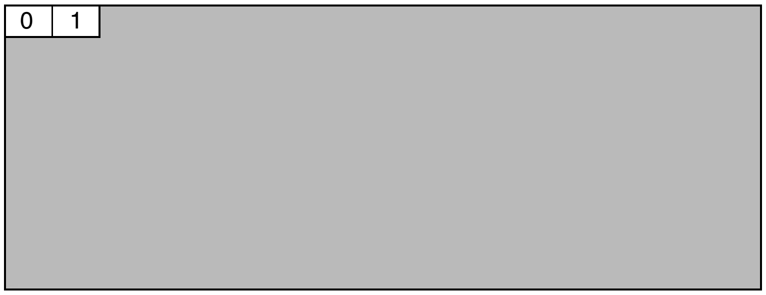


FIGURE 8-9: Diagram of Linux's Reserved Colors

TABLE 8-8: Linux Reserved Colors

Palette Entry	*Red Value*	*Green Value*	*Blue Value*	*Color Name*
0	0	0	0	Black
1	255	255	255	White

Macintosh

Table 8-9 shows the various color palettes supported under Macintosh-based systems.

TABLE 8-9: Color Palettes Supported by the Macintosh

Display Mode	*Color Palette Size*	*Comments*
640x480	16	Obsolete. Previously was the standard Macintosh display mode. No longer has any use in arcade game graphics, although it was used by many early Macintosh games until about 1994.
640x480	256	The standard Macintosh display mode. Commonly used and very popular with game developers. Has significant application in arcade game graphics.
800x600	256	A standard Macintosh display mode. Not as popular as 640x480 with game developers but starting to become more and more common in games.

The fact that the Macintosh's early operating systems only supported black and white means that only two palette entries are reserved by the system—black and white.

Table 8-10 shows their RGB values. These reserved colors include the first and last palette entries. All 254 remaining colors are completely user definable. This allows 256-color DOS images to be easily ported to the Macintosh. Unfortunately, 256-color Macintosh images won't port easily to the Windows platform without a bit of reworking and/or color loss.

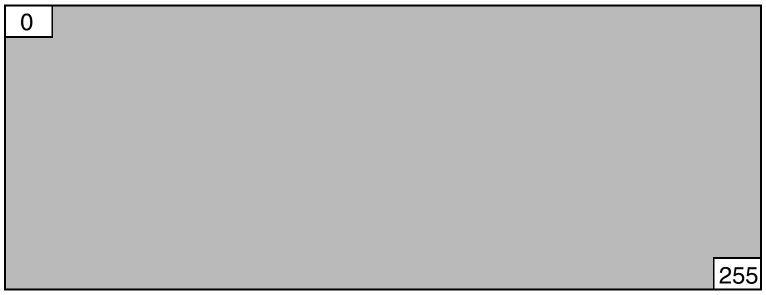


FIGURE 8-10: Diagram of Macintosh Reserved Colors

TABLE 8-10: Macintosh Reserved Colors

Palette Entry	*Red Value*	*Green Value*	*Blue Value*	*Color Name*
0	255	255	255	White
255	0	0	0	Black

Java

Java color palettes are determined by the platform the Java application is currently running under, and as such, they will inherit the particular palette handling quirks of the host system. So, for example, a Java game that runs under Windows will be subject to how Windows handles reserved colors.

NOTE: You can prevent this issue if you use the Java system palette described earlier in this chapter.

As each platform has its own peculiarities when it comes to the available number of palette entries, it's often easy to forget which restriction applies to which platform. Table 8-11 makes this process easier by compiling this information in one place.

TABLE 8-11: Available Palette Entries in 256-Color Display Modes by Platform

Platform	*Number of Available Colors*	*Palette Entries Affected*	*Comments and Restrictions*
DOS	256	0-15	All palette entries are open and legal to use but you should be careful not to blank out entries used by the BIOS/DOS text functions. Images can be easily ported over to the Macintosh or Linux systems and vice versa with little or no color loss.

Platform	*Number of Available Colors*	*Palette Entries Affected*	*Comments and Restrictions*
Windows 3.1, 95, 98, NT 4.0, and 2000	236	0-9, 246-255	20 colors are reserved for system functions and should not be changed. The first 10 and last 10 palette entries are essentially off limits to your palette. Images can be ported to other platforms with little or no color loss but the same does not hold true for images being ported to Windows. Because Windows supports fewer displayable colors, there will be some color loss when moving full-color Macintosh, Linux, and DOS images over to it.
Linux	254	0 and 255	All but two palette entries are free for use. The first and last palette entries are reserved for system use and should not be changed. Images can be ported from DOS, Windows, and the Macintosh platforms with little or no color loss.
Macintosh	254	0 and 255	All but two palette entries are free for use. The first and last palette entries are reserved for system use and should not be changed. Images can be ported from DOS, Linux, and Windows platforms with little or no color loss.

Creating Color Palettes

There's more to creating a color palette than just picking pretty or interesting colors. Creating an effective color palette actually involves careful planning and implementation. Let's look at the planning aspect first.

Planning a Color Palette

The planning phase happens before you actually define any RGB values and it examines such issues as:

- Game audience
- Game appearance
- Game mood
- Technical restrictions

Game Audience

This looks at who will actually be playing your game. Some things to consider when evaluating your game's audience include age, gender, and geographic/cultural influences of the game's potential players. Therefore, when analyzing the game audience, ask yourself such questions as:

- Is the game targeted towards younger players?
- Is the game targeted towards older players?
- What gender is your game targeted towards?
- Will the game be distributed or marketed overseas or made available for download over the Internet?

Remember that both older and younger users will perceive and react to color schemes differently. Younger audiences will prefer games that have palettes with warmer colors, while older audiences will prefer games with cooler colors.

The same holds true for genders. Be sure to consider this when designing your game's graphics.

Finally, if you're planning to distribute your game overseas or over the Internet, make sure you address any potential cross-cultural color issues that may affect your users.

Game Appearance

This determines the aesthetics of your game. Things to consider here are the desired look and feel you're interested in creating and the degree of realism associated with it. Therefore, as part of this analysis, ask yourself such questions as:

- What look or style are you trying to achieve?
- What colors will you need to produce that particular look?
- How long will your color gradients be?

The "style" you choose for your game can have a significant influence over your palette definitions. Generally, games with realistic design styles tend to emphasize palettes with more intermediate shades while games with retro or cartoon design styles tend to favor palettes with more intense primary colors in them.

Smoother shading is achieved by using longer gradients, so be prepared to reserve sufficient room in your palette if this is something you want to accomplish.

Game Mood

This examines the feelings and symbolism that you're trying to convey in your game. Things to consider when looking at this issue are the types of emotions that you're attempting to provoke in the player. Ask yourself this question: What mood and emotions are you trying to project to the user?

Remember the discussion in Chapter 7 about the impact that color can have on the user's mood and emotion. While you can always choose to ignore this factor without seriously affecting the quality of your game, why not take advantage of it? By selecting mood-enhancing colors, you can seize the user's emotions and get them fully immersed in your game.

Technical Restrictions

There are a number of technical issues that all games face. Of all of the items discussed so far, this is one of the most complex and frustrating issues to deal with when designing game graphics.

Technical issues can encompass everything from system-specific color capabilities to any special color effects you might want to create. Therefore, when looking at this issue, ask yourself these questions:

- Will the entire game share the same palette or will certain palettes be assigned to specific game levels?
- Will you use separate palettes for menu and title screens?
- What platforms will the game support—DOS? Windows? Linux? Macintosh?

Many games, regardless of their type, contain different levels. Each level can offer the user new and interesting challenges. One of the easiest ways of distinguishing between game levels is to introduce different color schemes. In many cases, this can be done without having to define a brand new palette. However, in some instances it will.

While 256 colors can provide you with many possible color choices, there will be instances where even this many colors can seem restrictive. Because of this, you need to make sure you have completely thought out how your game will handle implementing these level-based color schemes.

The same issue holds true for title and menu screens as well. In addition, let's not forget all of those annoying platform-specific palette differences!

NOTE: If you're unsure about any technical issue raised here, remember to ask your programmer! He or she should be able to fill in any of these gaps for you.

Implementing Your Color Palette

Once you have planned your palette, you will be ready to define its RGB color values and implement it. To do this, you'll need to use the Palette Selection tool that is specific to your particular painting program. Every program described in Chapter 5 allows you to define your own custom color palettes; however, they all differ somewhat in terms of features and ease of use.

Defining color palettes can be a tricky and tedious process. However, once you grasp the fundamentals, this process will eventually become easier. As with anything else discussed in this book, practice makes perfect.

It is best to break down the process of defining a color palette into several distinct steps. Doing this not only makes the process easier to manage, but it also allows you to back up in case you made a mistake. These steps include:

1. Defining the required color palette components
2. Deciding on a color palette order
3. Adding system colors
4. Selecting your colors
5. Defining your color ranges and gradients
6. Reserving palette entries for programmed effects
7. Testing your color palette
8. Saving your palette

Step 1—Defining the Required Color Palette Components

Each color palette should be broken down into several components. These components include elements such as:

- System colors
- Background color
- Transparent color
- Color ranges/gradients
- Special effect colors

System Colors

As previously mentioned, these are the colors that are reserved by the system for various housekeeping purposes, i.e., coloring windows and icons. Therefore, include them in every palette you define in order to prevent any unpleasant color distortions from occurring during the course of your game.

Background Color

You'll use this color for the background for your game artwork screens. There should only be one background color defined. Make sure that whatever color you choose has sufficient contrast. Very dark backgrounds such as black, dark gray, or dark blue provide excellent contrast when displayed against lighter colors.

NOTE: Traditionally, most programmers assume that palette entry 0 (the first color in the palette) is the background color. However, you are free to use any palette entry as long as you document it and notify your programmer about your selection accordingly.

Transparent Color

Unlike the transparent effects discussed in Chapter 7, transparent colors in the palette are used as *masks*, or stencils, that allow the contents of the foreground to be smoothly blended with the contents of the background. Transparent colors make it possible for irregularly shaped sprites to be used in games and are essential for creating smooth animation. Because of this, no palette should be created without defining a transparent color.

You can use any color at any palette entry as a transparent color as long as you document it and/or tell your programmer about it. However, whatever you do, never make the background color the same as your transparent color when creating a palette. Doing this can potentially cause any object shaded in with the background color (i.e., black) to "show through" when displayed. This effect is depicted in Figure 8-11.

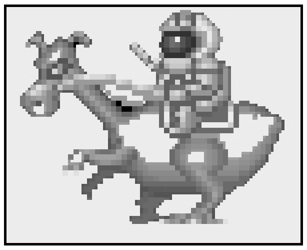


FIGURE 8-11: Background Color Showing through Foreground Object

NOTE: Different painting programs handle transparent colors differently. So, for example, specifying a palette entry as transparent in one painting program won't necessarily be reflected when you import the image into another. However, as long as you record the location of the transparent color in your palette, the transparent effect will be preserved when the image appears in a game.

Color Ranges/Gradients

Color ranges and gradients are colors grouped together for a special purpose such as to render a specific graphic object such as a rock or a tree. Although color ranges don't need to consist of related colors, they should be arranged according to their intensity with colors going from their highest intensity to their lowest intensity. Doing this will make working with your color gradients easier since there will be a visual cue as to which color to use next when shading an object, etc.

As a rule, it's considered good practice to place gradients and ranges that will be used to shade related objects next to each other in the palette. For example, a gradient that will be used to shade an object representing a tree trunk should be placed next to a gradient that will be used to shade the leaves. Doing this simply makes the process of locating commonly used colors easier and more intuitive.

NOTE: Color ranges and gradients are crucial to constructing a good color palette. Make sure you reserve plenty of room to accommodate them.

Special Effect Colors

Arcade games often make use of several special programmatic effects. These effects can include such items as:

- Register swapping
- Color cycling
- Color fades

Register swapping is a special programming technique that is used to simulate certain visual effects like the flickering of a torch or the flashing of a strobe light. To achieve this effect, the programmer rapidly changes the contents of a single palette entry and swaps in different RGB values at various speeds.

NOTE: As a designer, you really don't have to do anything to produce this effect other than reserving a palette entry for it.

Color cycling, also called *color shifting* or *color indirection*, is the ability to flash a series of colors on the screen in a linear fashion. This technique can be used to create very striking animations of repetitive actions. For example, you can use color cycling to simulate the flowing water in a waterfall, a roving spotlight, or the turning of a wheel.

Figure 8-12 demonstrates how color cycling works. Here, the "X" indicates the direction of the shifting color. To create the illusion of movement, the programmer rotates the contents of palette entries 224 through 231 by incrementing their position within the color palette by one entry at a time.

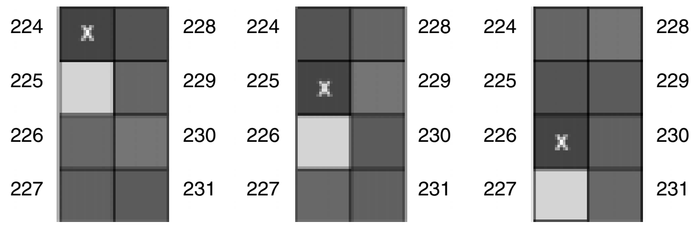


FIGURE 8-12: Color Cycling Mechanics

Although color cycling isn't necessary for most types of arcade games, it can be used to create some very interesting effects.

Traditionally, color cycling effects are handled by the programmer. As a designer, all you are responsible for is planning the color sequence and reserving the necessary palette entries for it.

NOTE: Color cycling was the hallmark of arcade games designed during the late 1980s and early 1990s but has since fallen into disuse. Consequently, very few program still support the creation of color cycling effects. However, both *Improces* and *Deluxe Paint* support the creation and previewing of this effect.

While there is no minimum number of palette entries required to achieve effective color cycling, the more palette entries you reserve, the smoother the animation effect will be. Table 8-12 provides some guidelines on how many color palette entries to use in order to achieve a particular type of color cycling effect.

TABLE 8-12: Color Cycling Palette Entry Reserve Guidelines

Number of Color Palette Entries	*Comments*
Less than 4	Produces a very coarse color cycling effect.
4-8	Produces a relatively coarse color cycling effect.
8-16	Produces a relatively smooth color cycling effect.
Greater than 16	Produces a smooth color cycling effect.

NOTE: Due to the limited number of color palette entries, it's advised that you don't use more than 16 palette entries for your color cycling effects unless necessary. In fact, you can usually create effective color cycling with as few as eight palette entries.

Color fading is another common visual used by arcade games. It is used as a means of transitioning in and out of title screens, menu screens, and game screens. Color fading can be smooth or coarse depending on the number of palette entries used to contain the effect.

Color fading works by filling in the contents of the palette with progressively darker RGB color values. When done properly, this has the effect of gradually "blanking" the contents of the screen. Figure 8-13 provides an illustration of the effect. Here, phases 1 through 4 represent the different stages of the palette being filled in with progressively darker colors.

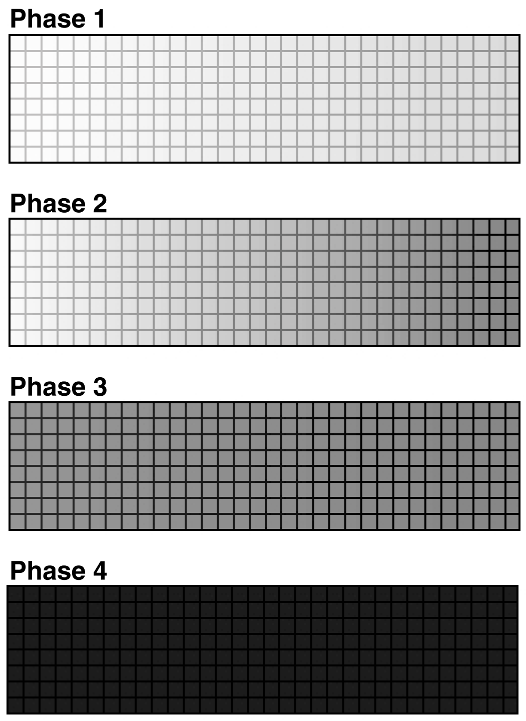


FIGURE 8-13: Color Fading (one box = one palette entry)

The number of palette entries used to create the effect has a direct influence on its quality. Table 8-13 provides some general guidelines for how many color palette entries to reserve in order to manage the quality of a color fading effect.

TABLE 8-13: Color Fading Palette Entry Reserve Guidelines

Number of Color Palette Entries	*Comments*
Less than 16	Produces a very coarse color fading effect.
16-32	Produces a relatively coarse color fading effect.
32-64	Produces a relatively smooth color fading effect.
64-128	Produces a smooth color fading effect.
Greater than 128	Produces a very smooth color fading effect.

NOTE: Due to the limited number of color palette entries, it's generally recommended not to use more than 128 palette entries for your color fading effects unless absolutely necessary.

NOTE: You are not limited to reserving only one section of your palette for special programmed color effects. In fact, you can reserve as many colors in your palette as you want for these effects. The only real limitations are your imagination and the number of colors you can spare for the effect.

In any case, none of these special color palette effects are necessary to create a good palette or a decent arcade game. Still, when done properly, they can enhance the visual impact of your game and should be seriously considered if you have the time to plan them and the appropriate number of color palette entries available in the palette.

Figure 8-14 illustrates the various color palette components of a typical color palette.

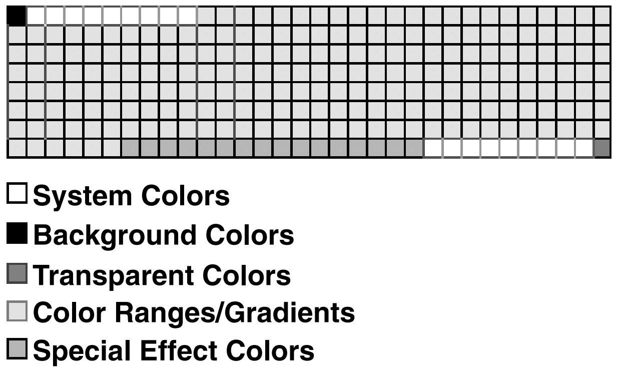


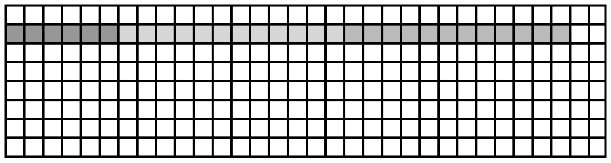
FIGURE 8-14: Color Palette Components

Step 2—Deciding on a Color Palette Order

In theory, you don't need to arrange your color palette entries in any particular order. However, in practice, you might want to do this as it offers two important advantages:

- **Makes colors easier to access**—Grouping similar or related colors together in the palette makes them easier to find and access. Doing this will save you time, particularly when working with colors that are used often. For example, if your artwork will contain trees or other vegetation, you might want to place your shades of green alongside shades of brown.
- **Better supports programmed color effects**—Color palette entries that are arranged in a specific and predictable order tend to make it easier for the programmer to implement programmed color effects. In addition to saving the programmer time, it enables these effects to be used consistently within a game.

This being said, it's good practice to spend time mapping out the order of your palette entries. Figure 8-15 shows an example of this.



▩ **Red Shades**
□ **Green Shades**
▨ **Gray Shades**

FIGURE 8-15: Color Palette Order

Step 3—Adding System Colors

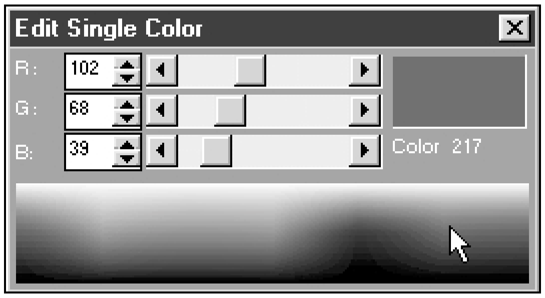
Always take the time to add your system colors to the color palette for the reasons discussed earlier in this chapter. Failing to do so can cause problems, particularly on Windows systems.

You can either add these colors manually using the RGB values specified in Tables 8-6, 8-8, and 8-10 or you can have your painting program do it for you. Be aware that certain programs such as *NeoPaint for Windows* provide features to do this, as do several of the palette tools offered by programs mentioned in Chapter 6 of this book.

Step 4—Selecting Your Colors

At this stage, you're ready to start picking your own color palette definitions. To do this, bring up the Color Selection tool in your painting program and simply manipulate the RGB (or HSV, HSL, HSB, etc.) color sliders to pick and blend the colors you want.

Moving the color slider down (or to the left in some programs) will cause the RGB value to get darker (closer to pure black) while moving the color slider up (or to the right) will cause the RGB color value to get lighter (closer to pure white).



Edit Single Color

R: 102

G: 68

B: 39

Color 217

FIGURE 8-16: Color Slider Example

One of the most challenging aspects of this step is figuring out what the specific RGB values are for a given color, particularly for the so-called "real-world" colors that we see and experience every day.

Want to know what color army green is? Or what the RGB color values for a flesh tone might be? Well, look no further. To help jumpstart the color selection process, Table 8-14 includes a list of several dozen "starter" colors.

TABLE 8-14: Starter Colors

Color Name	*RGB Color Values (Windows, Linux, Macintosh, and Java)*
Aqua	51 255 204
Army Green	128 128 0
Avocado	153 153 0
Banana	227 207 87
Bauhaus Gray	66 66 66
Black	0 0 0
Blue-Green	0 153 102
Boot Leather	160 68 0
Brick	204 102 51
Bright Blue	0 102 255
Bright Gray	192 192 192
Bright Green	0 204 51
Brown	232 168 144
Burgundy	153 0 51
Cadet Blue	96 156 152
Carrot	237 145 33
Castle Stone	41 41 41
Chartreuse	204 255 0
Cobalt	61 89 171
Coral	255 127 80
Crimson	204 0 51
Dark Blue	0 0 153
Dark Brown	104 52 0
Dark Gray	22 22 22
Dark Green	51 102 51
Dark Periwinkle	102 102 255
Dark Purplish Blue	102 0 204
Deep Purple	128 0 128
Deli Mustard	255 204 102

Color Name	*RGB Color Values (Windows, Linux, Macintosh, and Java)*
Dull Green	102 255 153
Eggshell	252 230 201
Fire Brick	165 0 33
Flesh	255 204 153
Florida Gator Orange	255 102 0
Fuscia	255 0 255
Gold	204 204 51
Golden Brown	153 102 0
Grass	51 153 102
Gray	128 128 128
Gray-Blue	0 102 153
Grayish Brown	152 140 104
Grayish Purple	153 153 204
Green	0 128 0
Gun Metal	150 150 150
Hot Pink	255 102 204
Indigo	8 46 84
Ivory	255 255 240
Khaki	240 230 140
Lavender	153 102 204
Light Beige	144 132 112
Light Blue #1	51 153 255
Light Blue #2	0 204 255
Light Brown	136 96 88
Light Gold	204 204 102
Light Gray	178 178 178
Light Orange	255 153 0
Light Plum	204 153 204
Light Rose	255 153 204
Light Yellow	255 255 102
Lilac	204 153 255
Lime	0 255 0
Linen	250 240 230
Maroon	128 0 0
Medium Blue	0 51 204

Color Name	*RGB Color Values (Windows, Linux, Macintosh, and Java)*
Medium Gray	85 85 85
Medium Green	0 153 0
Melon	227 168 105
Milk Chocolate	144 52 40
Mint	189 252 201
Navy Blue	0 0 128
Ocean Blue	56 176 192
Off White	227 227 227
Olive Drab	107 142 35
Periwinkle #1	153 0 255
Periwinkle #2	102 51 255
Pink	255 124 128
Pumpkin	255 153 51
Purple #1	102 51 204
Purple #2	102 51 153
Raspberry	135 38 87
Red	255 0 0
Red-Orange	204 51 0
Royal Blue	0 0 255
Royal Purple	102 0 153
Rust	112 0 0
Saddle Brown	112 76 48
Salmon	255 102 102
Sandy Brown	120 0 0
Sea Green	153 204 153
Sienna	204 102 0
Sky Blue #1	128 218 225
Sky Blue #2	0 220 255
Snow	255 250 250
Steel	102 102 102
Sun Yellow	255 255 0
Tan	204 204 153
Taupe	160 144 128
Teal	0 128 128
Tomato Soup	255 102 51

Color Name	*RGB Color Values (Windows, Linux, Macintosh, and Java)*
Turquoise	0 255 255
Ultra Purple	51 0 51
Wet Cement	184 156 152
Wheat	245 222 179
White	255 255 255
Wild Orchid	176 48 216
Wine	204 51 102

NOTE: It's interesting to point out that despite the fact that there are literally millions of colors in the visible spectrum, scientists and designers have only succeeded in naming about 7,000 distinct colors.

Step 5—Defining Your Color Ranges and Gradients

Using your painting program's Color Selection tool, define your color ranges and gradients and place them in the areas that you reserved during Step 2 of this process. As mentioned in Chapter 5, most painting programs provide options to do this for you automatically.

Color ranges and gradients are extremely useful as they allow you to choose two different colors and create a bridge of intermediate shades between them. For example, to make a range of flesh tones first create two extremes of color that would best represent flesh. In this case, off-white and medium brown would work. The numbers of color palette entries between these two end colors determines how many colors will actually be generated between them. More palette entries will produce a smooth gradation of color, while fewer palette entries will producer a coarser gradation of color.

Finding the optimal number and arrangement of color ranges and gradients takes time and experience. Expect to spend a fair amount of time experimenting to get the right balance.

If you're short on time or just impatient, consider looking at Table 7-7 for suggestions on how to define and optimize the size of your color gradients.

NOTE: The colors defined in Table 8-15 are good starting points for creating color ranges and gradients. Just make sure to always define a starting color and an ending color, i.e., which color is lighter or darker. If there aren't two intensity extremes between the start and end of the gradient, the effect won't take.

Figure 8-17 illustrates how a color range or gradient might actually look in your palette. Min represents colors with the lowest intensity (darkest) while Max represents colors with the highest intensity (lightest).

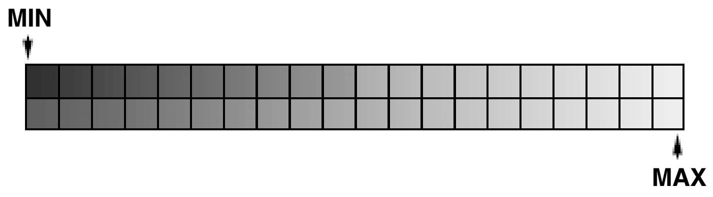


FIGURE 8-17: Example of a Color Gradient in a Color Palette

Every game object, regardless of its function, has some color or set of colors associated with it. For example, apples are red, rocks are often rendered in shades of gray or brown, leaves are green, water is blue, etc. Yet, given the fact that you can choose from thousands if not millions of colors from the hardware palette, it can often be difficult to figure out exactly which colors should go with what object.

To help with this, take a look at Table 8-15 as it provides some general suggestions for which game objects go best with which color gradient definitions.

TABLE 8-15: Color Gradient Usage Suggestions

Color Gradient	*Suggested Use(s)*
Reds, yellows, and oranges	Explosions and fire
Various shades of blue	Assorted surface structures, sky, ice, and water
Various shades of brown	Earth, asteroids, wood, flesh, and rock formations
Various shades of gray	Assorted metallic alloys, stone, and smoke
Various shades of green	Vegetation
Various shades of magenta	Rock formations, assorted flora, and cloth
Various shades of pink	Flesh
Various shades of red	Blood, lava, and assorted surface structures
Various shades of tan	Flesh and earth
Various shades of yellow	Sunlight and treasure

NOTE: To save you time and effort defining your own color gradients, the CD-ROM included with this book features over 50 predefined gradients that address virtually any game related need. These definitions can be found in the `PALETTES` directory in the file labeled `starter_palettes.html`.

Step 6—Reserving Palette Entries for Programmed Effects

If you plan to take advantage of any special programmatic effects such as color cycling or palette fades, this is the point in the palette definition process when you would reserve palette entries for them. The reason this comes up so late in the process is two-fold:

- As programmed effects are not central to your game artwork, your main drawing colors have priority in your palette.
- Programmed effects are often removed from the game at the last minute for various reasons. By adding them last, you can easily reclaim the palette entries they occupied with a minimum of fuss should they be removed later on in the game development cycle.

Step 7—Testing Your Color Palette

After you define your system colors, individual colors, and color gradients, you should always test out your palette before using it in a game. This is an extremely important step since what looks good in your Palette Selection tool won't always look good when in actual use. To see if your palette actually passes muster, try one or more of these procedures:

- The contrast test
- The light/dark test
- The gradient test

The Contrast Test

This particular test evaluates the contrasting qualities of the colors in your palette. As mentioned in Chapter 7, colors without sufficient contrast undermine many of the advantages that color can offer your game.

To determine this, draw some simple shapes on the screen using your current palette definitions, then see how they contrast with each other. Do they look okay? If not, something is wrong with your palette; you'll need to redefine the problematic colors and test your palette again until they do.

The Light/Dark Test

This test evaluates the relative lightness or darkness of the colors you have chosen for your palette.

To perform this test, alternate drawing several test objects against both dark and light backgrounds and see how things look. Do the colors seem too dark? Do they appear to be too light? If so, fix the offending color values in your palette and test again.

The Gradient Test

This test examines how well the colors you've selected blend together. This is important since colors that don't blend well also don't shade well.

To perform this test, create some shapes and fill them with color gradients. Next, take a close look at how the colors within these shapes blend and ask yourself questions like these:

- Are your gradients large enough for the level of shading you want to achieve in your artwork?
- Are they too coarse?
- Is there enough contrast between gradient colors or are they too similar?

If you discover a problem here, go back in your palette and tweak your color selections until the problems you identify in this test vanish completely.

In short, it always pays to play around with your color palette and look for potential problems that might crop up before you start using it in your artwork. Believe me, it's far better to discover a potential problem with the contents or organization of your palette now rather than later when you're in the middle of a major project. By that point, it might be too late to start making wholesale changes to your palette.

Step 8—Saving Your Palette

When you are satisfied with how your palette looks, it's time to save your palette to disk. Whenever possible, try to save your palette in the Microsoft .PAL format, as this will help make your color palette definitions portable across different graphics applications and development environments.

NOTE: Please be aware that several programs mentioned in Chapter 6 and included on the book's CD-ROM save palettes as .PAL files. However, some of these are actually saved in proprietary formats and not in the Microsoft-compatible .PAL. format. Always make sure that you save your palettes in the correct .PAL format, especially if you want to be able to share your color palettes with different programs.

A Color Palette Creation Exercise

This section will quickly review the basics of actually defining a color palette. For this example, we'll use *Pro Motion*, an excellent Windows-compatible painting program that is described in more detail in Chapter 6. *Pro Motion* was selected for this exercise because of its powerful color palette manipulation features.

NOTE: Virtually all of the other painting programs mentioned in Chapter 6 offer similar methods for defining the color palette. The only real difference between them and *Pro Motion* is how this operation is actually performed.

1. Start up *Pro Motion* (a demo is available on the book's CD-ROM; see Appendix B for details) and select the **Colors** menu.
2. Select the **Load Palette** option. This brings up a dialog box. Navigate so that you are inside *Pro Motion*'s Palettes directory as shown in Figure 8-18. This directory contains several predefined color palettes that come with the program. The one we're interested in is called win256.pal. This palette file contains the definitions for the Windows 256-color system palette described earlier in this chapter. It was chosen for this exercise because it already contains Windows' 20 reserved colors in their proper places.

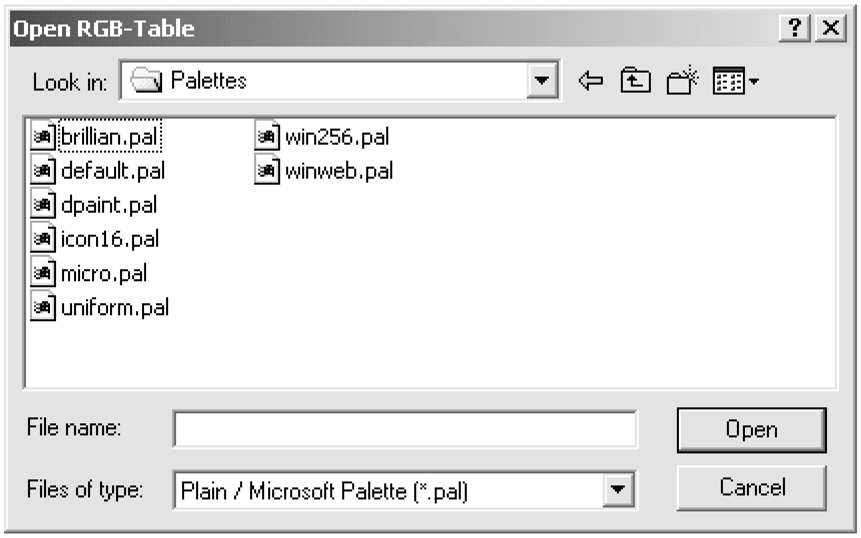
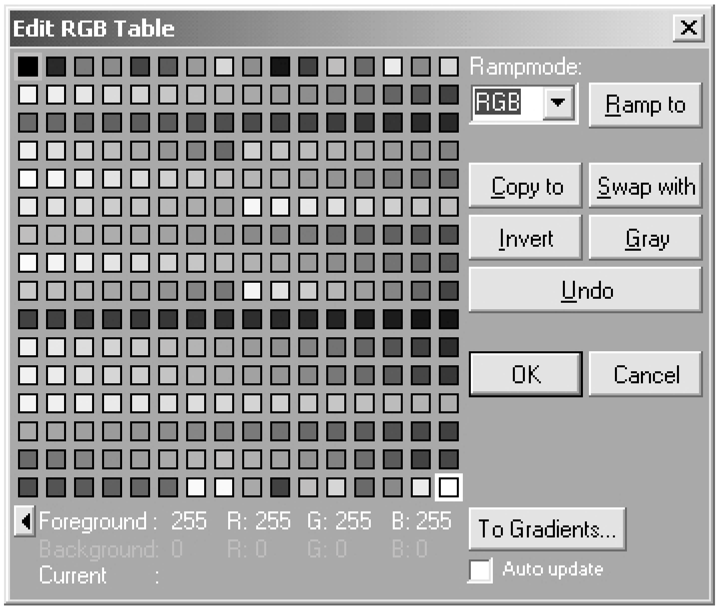


FIGURE 8-18: Palette Load Dialog

3. Select it and choose **Open**. You will notice that color bars at the top left of the screen will change to reflect the new color palette definitions. If they don't, repeat the operation until they do.
4. Go back to the Colors menu and choose the **Edit Palette** option. Doing this brings up *Pro Motion*'s Edit RGB Table dialog (Color Palette tool) as shown in Figure 8-19. This tool presents the current color palette's 256 color definitions in a 16x16 grid. Clicking on any colored box in this dialog will display its RGB color values and its order within the palette. Two colored boxes also appear on the screen and surround two color palette entries. The white box represents

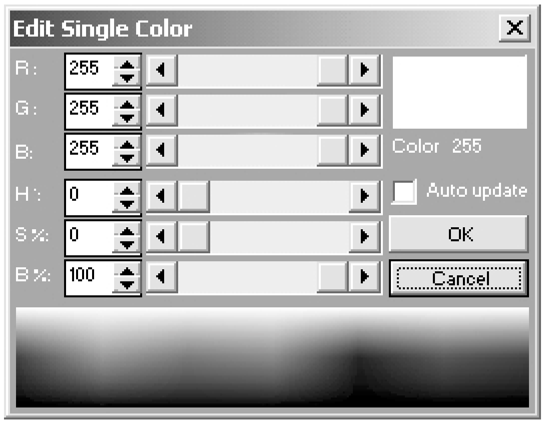
the foreground color, or the start-point of your color gradient. The green color represents the background color, or the endpoint of your color gradient.



Foreground : 255 R: 255 G: 255 B: 255
Background: 0 R: 0 G: 0 B: 0
Current :

FIGURE 8-19: Edit RGB Table (The Palette Tool)

5. Click on the small left-arrow button located at the bottom of this dialog. This brings up *Pro Motion*'s Edit Single Color dialog as shown by Figure 8-20. From here, you can define the individual colors of the color palette by manipulating the RGB or HSB sliders. In addition, you can visually select colors from the color spectrum located at the bottom of the dialog.

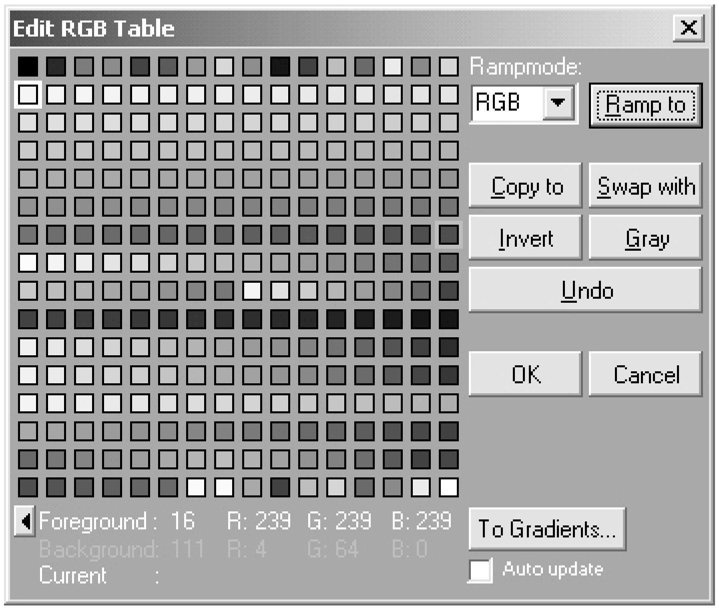


R: 255
G: 255
B: 255
H : 0
S %: 0
B %: 100
Color 255

FIGURE 8-20: Edit Single Color Dialog (The Color Editor)

6. To define a color gradient/range, switch to the Edit RGB Table dialog and click on the color palette entry where you would like the gradient to start. As you do this, the white box will surround your selection.
7. Next, go to the Edit Single Color dialog and define a color for the selected palette entry.
8. Now, select a background color by right-clicking the mouse button on the palette entry that marks the end of your gradient and repeat step 7. Just remember the rules on gradients discussed in Chapter 7!

When done, switch back to the Edit RGB Table dialog and click on the **Ramp to** button. The mouse cursor will change to a cross hair. Click on the green box and *Pro Motion* will automatically compute the color shades that fit between your foreground and background color selections as shown in Figure 8-21.



Foreground : 16 R: 239 G: 239 B: 239
Background: 111 R: 4 G: 64 B: 0
Current :

FIGURE 8-21: Successfully Defined Color Gradient

NOTE: *Pro Motion* will only allow you to define gradients that run from the foreground to the background. The opposite won't work in this program; however, some painting programs do support this feature.

9. To define the remainder of your palette, simply repeat steps 6 through 9 until the palette is defined to your liking.
10. You can use the button labeled Copy to to copy single color palette definitions to other areas within the palette. You can use the Swap with option to exchange the positions of individual color palette definitions within the

palette. The Gray button automatically converts the current foreground color to its equivalent RGB gray value. The Invert button replaces the contents of the currently selected foreground color with its mathematical inverse. Finally, the Undo button undoes the last operation or change you made.

11. When done, select the **OK** button. This will cause the program to automatically accept your new palette definitions. If you want to permanently save the palette, go to the Colors menu and choose the Save Palette option. A dialog box will appear as in Figure 8-22. Select **Microsoft Palette** in the Save as type box and choose **Save**.

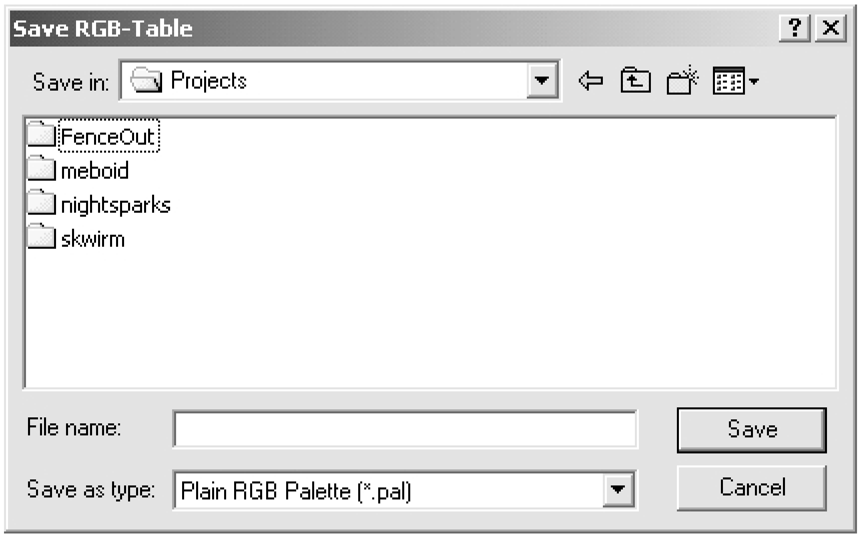


FIGURE 8-22: Save RGB-Table Dialog

Tips for Creating Effective Color Palettes

This section provides some useful tips on creating, defining, and editing your own color palettes.

Gradient Selection

- **Avoid wasting colors**—For many palettes, it's suggested that you arrange your color gradients so that colors go from the highest intensity to their lowest intensity. However, be careful not to waste available color palette entries by using redundant colors (colors that have already been defined) or by filling them in with shades that don't differ substantially in contrast from one other.

- **Build gradients with consistent intensity and saturation**—Gradients that feature consistent intensities and saturations tend to be more flexible than gradients that do not. In addition to keeping your color selections uniform, doing this allows the contents of these gradients to be easily colorized. The Colorize function was discussed in Chapter 6.
- **Conserve colors intelligently**—Remember that you don't always have to use very long color gradients (ones that go from minimum to maximum color intensity) for your palettes. Instead, you can use any gradient length as long as it contains enough shades so that you can render objects that maintain the illusion of realism. Doing this will help you conserve colors in your palette for other purposes.
- **Make logical color selections**—Your color selections should closely mirror the user's expectations. In other words, you don't want to select colors that seem out of context. For example, water should be a shade of blue and not purple. Trees should have brown trunks and not red, etc. Doing this will enhance the character of your artwork and maintain the suspension of disbelief.

Programmed Color Effects

- **Place palette entries adjacently**—In order to work, programmed effects such as color fades and color cycling require that color palette entries be placed adjacently.
- **Test your color cycling**—Whenever possible, test any color cycling effects that you create prior to handing them off to the programmer. You can do this by previewing them with any program that supports color cycling so that you can discover any potential problems with your implementation sooner rather than later.
- **Be conservative**—Don't be greedy. Remember that you will need plenty of colors to render your main game objects so don't reserve too many color palette entries for special effects at the expense of your normal drawing colors. As I said earlier, drawing colors should always have priority in your palette.

Transparent Colors

- **Use two blacks**—As black is commonly used as both a background and transparent color, it's a good idea to reserve a second shade of black (RGB: 0,0,0) somewhere else in your palette. This way, you can use black as much as you want in your artwork without having to worry about the contents of the background showing through your foreground objects.

Miscellaneous Color Palette Tips

- **Borrow color palettes from other games**—If you have trouble coming up with your own color palette definitions, or are like me and just plain lazy, you can always borrow color palettes from other games. To do this, simply use one of the screen capture utilities described in Chapter 6 and capture a game screen that interests you. Next, use a palette tool (also described in Chapter 6) to extract the contents of the image's palette. Doing this can give you excellent insight on how to use color in your games in addition to saving precious time.
- **Use a scanner to obtain "difficult" colors and shades**—Certain colors, such as those used for flesh tones, can be very difficult to accurately reproduce manually when defining a color palette. One of the best ways to determine which colors to use is to let the computer determine the color values for you. You can do this by scanning in a photograph from virtually any magazine into your favorite image editor or painting program and then copy the RGB values it uses to represent areas of flesh into your palette.
- **Try to leave sufficient space at the end of your palette**—You are bound to define color ranges and gradients that don't fit the feel of your artwork as the game evolves. Because of this, you should always leave room at the end of your palette for additional or "replacement" gradients that you can use instead. Doing this will reduce the possibility of you having to scrap any artwork rendered with your existing color palette.

Color Reduction

There will come a time in creating arcade game graphics when you will need to either reduce the amount of colors contained in an image or remap the contents of one palette with the contents of another. Often, you will have to do both.

Color reduction is the process used whenever you need to take an image you made in a high color display mode and want to use it in a display mode that only supports 256 colors (i.e., 8-bit).

Palette remapping is a subset of the color reduction process. It's used when you need to convert an image that was made using colors from one palette and incorporate this image into a different palette. Even if some or all of the colors are the same between the two color palettes, their different palette orders prevent the image from displaying correctly when it is converted over to the new color scheme.

Fortunately, most of the programs mentioned in Chapter 6 can perform color reduction on images; however, their results vary wildly depending on the images used and the options selected.

There are essentially three color reduction methods. These are:

- Palette optimization
- Dithering
- Straight color remapping

Palette Optimization

This color reduction method uses several different algorithms that analyze the contents of both images (the original the new image). It then looks for similarities between the colors contained in both images and weighs them accordingly. The more colors that match in both images, the better the results.

NOTE: There are great disparities between the various palette optimization algorithms in common use. Some work better on certain types of images while some work better on others, etc. In the end, your best bet is to experiment.

Dithering

As mentioned in Chapter 2, dithering is a technique for simulating colors that are missing from an image's palette. By blending pixels of two or more palette colors, a third color can effectively be simulated. In many ways, dithering is very similar to mixing paint and in the proper circumstances, dithering can produce excellent results.

The main drawback to dithering is this: if the unavailable colors differ too much from the originals, the dithering will produce images that look spotty, grainy, and coarse, especially when compared to the original image. See Figures 8-23 and 8-24. Like palette optimization, dithering works best on images that have similar colors in them.

Dithering is frequently used when designing complicated shades for display on screens that do not support large color palettes (i.e., 16-color) and in the hands of a skilled artist, can be used to create fairly convincing and attractive artwork. In this situation, dithering can effectively simulate hundreds of additional shades and colors, making it particularly useful when creating artwork destined for online use (i.e., the Web).

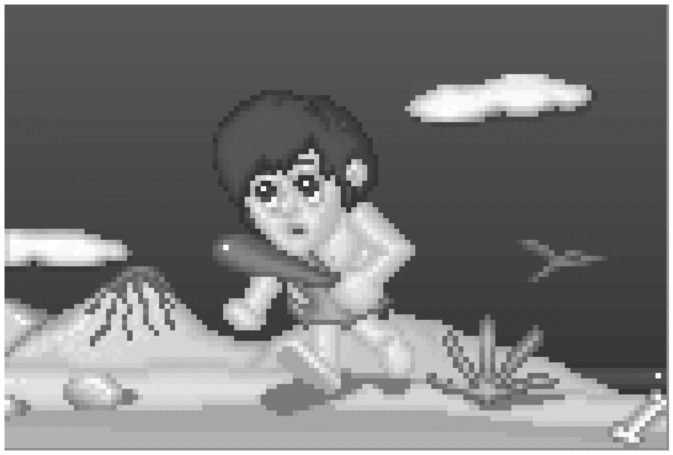


FIGURE 8-23: Original Image

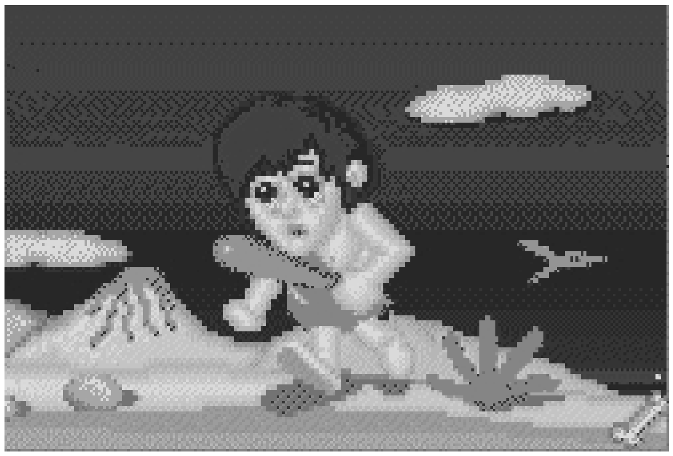


FIGURE 8-24: Dithered Image

NOTE: Dithering is often combined with palette optimization to produce better results, especially when dealing with reducing 24-bit images down to 8-bit color, etc.

Straight Color Remapping

This technique simply does a one-for-one swap of colors between the original image and the target. While this technique is very fast, the results are often less than stellar. This is because straight color remapping works best on images that have similar numbers of colors in them. Figure 8-25 shows the results of color remapping. Compare it to the original image as seen in Figure 8-23 and you will notice that much of the color fidelity and shading of the original is lost in the remapped version.

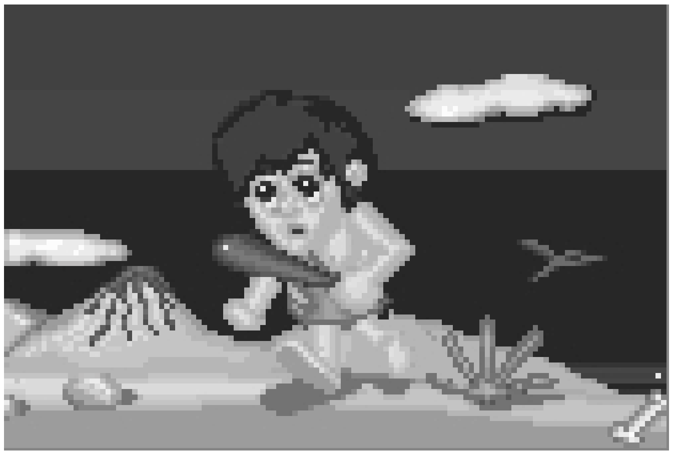
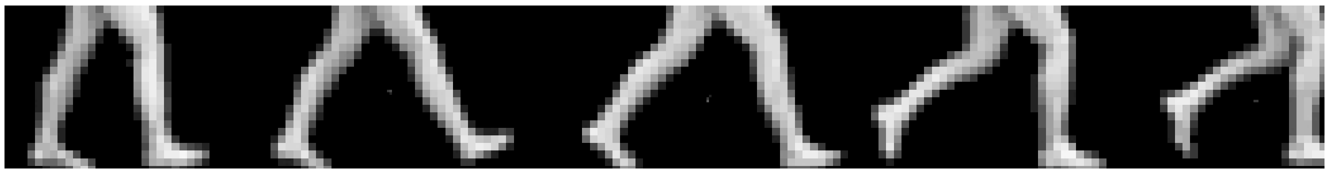


FIGURE 8-25: Straight Color Remapped Image



Chapter 9

Arcade Game Animation

In this chapter, you'll learn about:

- **Animation**
- **Animation properties and fundamentals**
- **Sprites and grid squares**
- **Core arcade game animation techniques**
- **Creating animation sequences for arcade games**
- **General animation tips**

What is Animation?

Animation is the process that produces the illusion of movement. It works by displaying two or more image fragments called *frames* (also commonly referred to as *cells*). When these frames are displayed in rapid succession with subtle changes made to their content, our eyes register these changes as movement.

Animation is not a mystical art. Rather, it's a well-established process that combines the aesthetics of design with real-world physics in order to breathe life into what are otherwise static objects and scenes. This chapter will introduce the fundamental concepts behind animation to you so that you can create and implement animation in your own arcade game projects.

Animation Properties and Fundamentals

To be able to create effective animation, you must learn how to divide the elements of motion into their basic components. This means breaking them down into a sequence of easy-to-follow frames. However, before you can do this, you must first learn and master two things: the art of observation and the characteristics of basic motion.

The secret behind creating great animation lies in keen observation and the ability to focus on the subtle details of how different objects move. Every object exhibits certain peculiarities as it moves. Some of these idiosyncrasies are slight while others are more pronounced. As such, there are several characteristics of motion that you should be aware of before attempting to animate an object. These characteristics include such things as:

- Motion lines
- Motion angles
- Key-frames and in-betweens
- Weight and gravity
- Flexibility
- Secondary actions
- Cycles and loops
- Tempo

Motion Lines

A *motion line* (sometimes referred to as a *natural path*) is an invisible line created by an object as it performs a series of sequential movements.

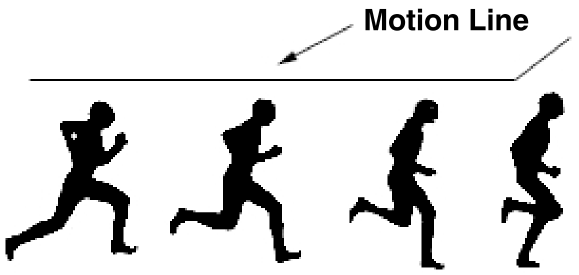


FIGURE 9-1: Motion Line Example

Motion lines are essential to creating effective animations, and manipulating the motion line can add realistic emphasis to animated objects. For example, you can create very smooth animations by making small alterations to the motion line. Conversely, you can produce very dramatic animations by making large or exaggerated changes to the motion line.

Even more interesting to the animator is how objects produce different shaped motion lines depending on how they move. For example, a bullet has a motion line that is straight and even while a bouncing ball has a motion line that is wavy and uneven. This being said, motion lines must be consistent with an object's real-world behavior in order to produce realistic-looking animation. Otherwise, the quality of the animation will suffer. Therefore, you can use an object's motion line as a means of determining whether or not it is being animated correctly and convincingly.

The best way to follow an object's motion line is to locate its *center of gravity*. The location of the center of gravity varies according to the type of object involved.

To help you accomplish this, Table 9-1 provides some examples of where the center of gravity is for a number of common objects. Using this information, you should then be able to identify the center of gravity for other types of objects.

TABLE 9-1: Location of the Center of Gravity in Different Objects

Object Type	*Estimated Center of Gravity*
2-legged animals	Head
4-legged animals	Chest
Flying animals	Torso
Humans	Head
Insects	Torso
Spaceships or airplanes	Hull or fuselage
Tracked or wheeled vehicles	Turret or body

Motion Angles

Motion angles are one of the most obvious clues as to an object's direction as it moves. It's important to point out that there is a direct relationship between an object's direction and its motion angle. Almost any change in an object's speed or direction will require a similar adjustment to its motion angle. Therefore, the sharper the motion angle, the faster or the more extreme the change in the object's motion or direction will be.

Motion angles are particularly useful for conveying a sense of realism in animated objects. For example, a jet fighter making a steep bank will have a motion angle that is sharper than a jet fighter that is flying straight and level as shown in Figure 9-2. In this case, you can use its motion angle to visually discern that it is traveling at a high speed, which ultimately helps to reinforce the illusion of realism.

Although the actual location of motion angles varies, most motion angles are located along the spine of an object, i.e., the backbone of a human being or the hull of a spaceship.

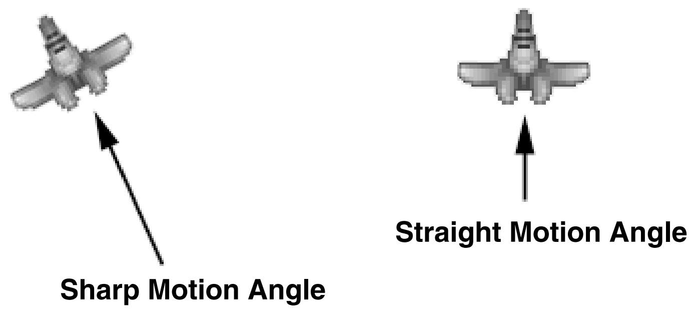


FIGURE 9-2: Motion Angle Example

Key-frames

Most people are aware of the extremes that occur during movement, i.e., such noticeable things as the flapping of wings or kicking of legs. In animation, we refer to these actions as *key-frames.*

Being able to determine which frames in an animated sequence are the key-frames is an extremely important part of the animation process. This is because key-frames serve as the framework for the entire animation sequence.

In addition, there is a direct relationship between the number of key-frames used and how smooth a particular animation appears. The presence of more key-frames in an animated sequence means smaller incremental changes in the animation and results in smoother overall movement. Having fewer key-frames present, on the other hand, results in coarser and jerkier animation. Please keep this very important relationship in mind as it has a direct effect on the quality of any animation you create.

Key-frames are most effective when they incorporate very exaggerated or dramatic elements, since these actions can be used to emphasize the most critical movements in an animated sequence. In addition, exaggeration can help you to better determine the most effective starting, middle, and ending points for an animated sequence. For example, Figure 9-3 shows the two key-frames for a bird flying. Notice how they mirror the two extreme states of the action, i.e., the wing moving up and the wing moving down. These two frames are extremely exaggerated, which makes them ideally suited as key-frames because their differences are clearly distinguishable to the observer.

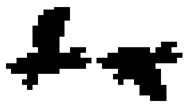


FIGURE 9-3: Key-frame Example

It's important to realize that the more key-frames a particular animation has, the more complex it is and the longer it will take to design. This is certainly something to consider when designing the artwork for an arcade-style game, especially when working under a tight deadline. In addition to taking longer to create, complex animations make it easier to introduce errors and mistakes into the animation sequence, which can have a negative impact on the animation's overall quality and effectiveness.

In reality, however, the actual situation dictates which approach to take and how many key-frames to use for a given animation.

There will be instances where you can get away with using fewer key-frames than in others. In most cases, you can use as few as two or three key-frames per object in arcade-style games, with little or no detrimental impact. However, you should look at each game on a case-by-case basis before deciding on a particular number of key-frames to use. If you don't, you run the risk of reducing the quality of your game's animations and, ultimately, the quality of the game.

Please refer to Table 9-2 for general suggestions on key-frame usage in different arcade game genres.

TABLE 9-2: Object Key-frame Quantity Suggestion Chart

Arcade Game Type	*Key-frame Usage Suggestions*
Pong games	2 per animated object
Maze/chase games	2-3 per animated object
Puzzlers	2-3 per animated object
Shooters	2-4 per animated object
Platformers	2-6 per object

NOTE: These are subjective estimates only. Each game situation will be different and will depend on the design time, the game's target platform, and the overall level of animation quality you want to achieve.

It's important to note that key-frames can occur at any point within an animated sequence. However, certain factors such as the type of animation involved and its relative complexity can influence where in the sequence they might actually appear. For example, non-repetitive motions such as explosions have many key-frames and tend to be located at several points within the animation sequence or wherever there is a major change. In comparison, repetitive motions such as walking or flying have only a few key-frames (i.e., two or three). These tend to be distributed at the start, middle, or end of the animation sequence.

After the key-frames of the animation are identified and established, the *in-between* frames must then be added. In-betweens are frames of animation that are used to smooth out the transition between individual key-frames.

In animation, key-frames are important for defining the object's primary movements, while in-betweens are responsible for making the entire animation look smooth and convincing. Introducing slight or subtle changes to each frame between key-frames creates in-betweens. This process is also known as *tweening*, and great care must be taken to ensure that these changes are small in order to maintain the illusion of continuous and realistic movement.

Figure 9-4 shows an example of how in-betweens co-exist with key-frames. This example shows an animation of a man swinging a stick. The start of the sequence shows the man with the stick up at the shoulder and ready to swing, while the final frame shows the end of the swinging process with the stick fully extended. These are the key-frames of the animation while the frames that occur in-between them are the in-betweens of the animation.

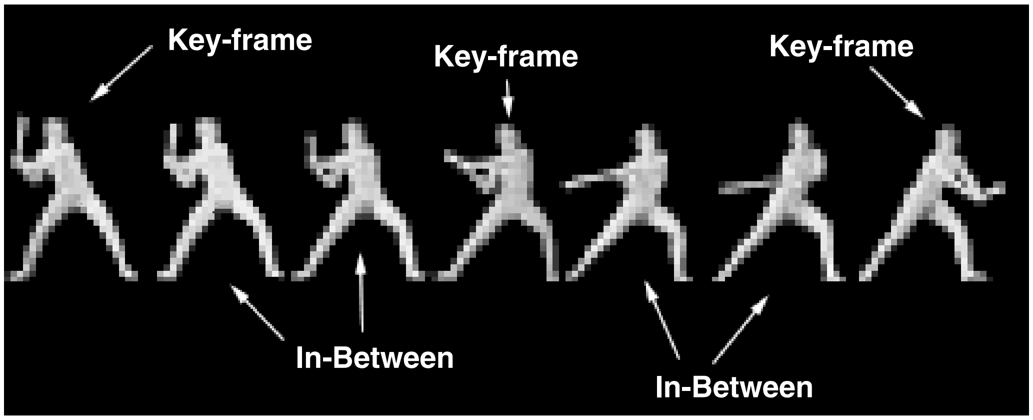


FIGURE 9-4: Key-frame and In-Between Example

Creating in-betweens is one of the most tedious and time-consuming aspects of designing arcade game animation. Fortunately, most painting programs allow you to easily duplicate existing frames so that each in-between doesn't have to be re-created entirely from scratch. In traditional animation, the process of duplicating an existing frame of animation to create a new one is called *onion skinning*.

Determining the number of frames necessary for creating a particular type of animated movement takes time and experience to figure out. To help you on your way, Table 9-3 lists the number of frames required to produce a variety of different animation effects. Use these as a general guide if the issue is ever in question in your own game projects.

TABLE 9-3: Common Frame Animation Frame Requirements

Object	*Minimum # of Frames*	*Maximum # of Frames*
4-legged animal running	4	16
Animal biting	2	5
Crawling	2	12
Explosions	5	16
Falling	3	5
Flying	2	12
Jumping	2	10
Kicking	2	6
Punching	2	6
Rotating/spinning	4	16
Running	2	12
Swinging (an object)	2	8
Throwing (an object)	2	6
Vehicle flying	2	4
Vehicle moving	2	8
Walking	2	12

Weight and Gravity

If you intend to create realistic-looking game animations, you must consider how the elements of weight and gravity can affect your work. When designing animation, you must remember that real-world physics should always apply to the sequences that you create. One of the most important of these influences is that of weight. Weight affects speed. So, for example, the larger the object, the heavier it is and the slower it is likely to move.

In addition to influencing the speed at which objects travel, weight can also affect how easily an object can move. For example, think about how fast a racecar moves in comparison to a battle tank. The tank will plod across the ground whereas the racecar will quickly skim across it. This is because the racecar weighs less.

Then there's the issue of gravity. Gravity also influences the motion of objects. In the real world, gravity will exert more force (resistance) against heavier or denser objects than it will against lighter ones. To see how this works, consider how quickly a bomb falls from the sky when compared to a feather, or how a rock bounces off the ground in comparison to a rubber ball. Remember that people aren't always easily fooled. Believe me, they are well aware of such things and failing to account for these behaviors in your animations can have a negative impact on how they are perceived in a game.

Incidentally, the principles of weight and gravity can be applied to virtually any animated object. Therefore, the more attention you pay to them, the more realistic your animations can be.

Flexibility

Flexibility is essential to producing convincing and fluid animation, particularly when depicting complex, jointed objects such as animals, insects, and human beings. Animations without proper flexibility can appear stiff and rigid, which for these types of objects is a less than desirable effect.

The key to adding flexibility to your animations is careful planning coupled with careful observation of how different objects behave when they move. Whenever you animate a jointed object, you must always determine which parts of the object (i.e., arms, legs, etc.) lead the movement and which ones follow it. It's very important to realize that not all body parts actually move at the same time on all objects. For example, consider how a swordsman might slash with his sword. The swordsman leads with his legs first to gain a solid footing and then follows through with his arm to complete the cutting motion. In animation, this flow of movement is called the *range of motion*.

When attempting to incorporate flexibility into an animation you must take care to account for the limits of anatomy. That is to say, never attempt to unrealistically extend the available range of motion that a given object has. Don't depict objects moving in ways that aren't possible in the real world. Examples of this might include, but aren't limited to, such things as bending a joint backward or in a position that is not normally possible for one to make.

Secondary Actions

As mentioned in the previous section on flexibility, not all parts of an object move simultaneously when animated. There are parts that lead the flow of movement and parts that follow it. The parts that follow the movement are called *secondary actions*.

Secondary actions are extremely important to the animation process because they add an extra dimension of realism to animations. Essentially, anything that is free moving can qualify as a secondary action. This includes everything from hair and clothing to eyes and lips. So, for example, if a character in a game is wearing a cape and walking, the secondary action of this action would occur when the character's cape bounces and sways as the character moves. Figure 9-5 shows this in frames 1 and 2.

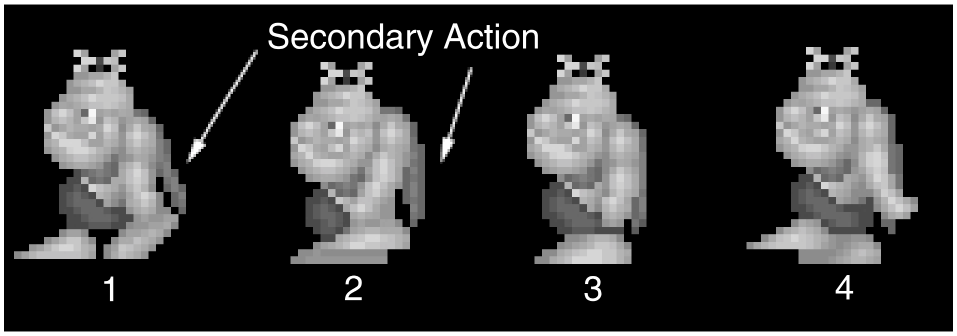


FIGURE 9-5: Secondary Action Example

Secondary actions are not limited to small details such as clothing or hair. It's important that you understand that they can be virtually anything in an animation sequence that isn't the main focus.

Cycles and Loops

In animation, *cycles* are the repetitious movements that many animated objects make when displayed in a sequence. As your ability to observe how objects move in nature improves, you will soon discover that many objects include cycles in their movements.

Cycles can be considered the time savers of the animation process. They help us avoid the tedium of constantly having to re-create frames to construct basic actions. For example, without cycles you might have to draw hundreds of frames of animation to show a bird flying across the screen. However, by using cycles, you simply have to identify the object's repeated motions and display them instead. So, if your bird animation used 30 frames to display the complete animation sequence you would only have to draw the three or four frames that best represent the major points of movement. Although key-frames usually fall into this category, it's important to realize that there isn't always a direct one-to-one relationship between key-frames and cycles.

While cycles focus on repeating the occurrence of specific frames within an animation sequence, *loops* emphasize the repetition of the entire sequence as a whole. For example, an animated sequence of a man walking goes through a number of frames to produce the illusion of movement. By looping the sequence, you can simulate the effect of constant motion so that the walking sequence appears to be continuous. Therefore, it can be said that loops help us to keep animated movement constant.

However, this being said, it's important to understand that not all objects require constant motion while being animated. Loops are a device to help us achieve this but they shouldn't be used in all animations. In fact, quite a few types of animation don't rely on loops at all.

In addition to adding realism and continuity to your animations, looping can also save you time by preventing you from having to manually repeat the individual frames of the entire animation sequence.

Figure 9-6 shows an example of how cycles and loops work together in animations. Here, frames 1 and 5 are cycles because they are repeating the same frame of animation. When the sequence reaches frame 5, it would loop back to frame 1 to create the illusion of continuous movement.

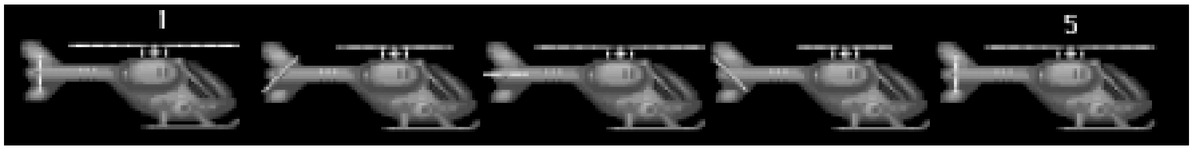


FIGURE 9-6: Cycle and Loop Example

Tempo

Every animated object can display at a specificed *tempo*, or speed. Tempo can be used to control the rate at which entire animation sequences are shown as well as the speed of the individual frames that comprise the sequence.

Tempo is important because it allows us to create more realistic-looking animation sequences. Its usefulness becomes immediately apparent when you consider that most real-world objects move at different rates during the course of their movements. For example, consider the average marathon runner. When running, a marathoner's legs move faster during mid-stride than they do when they are fully extended. You can account for this fact in your own animations by using the distance of the object between successive frames as a means of depicting animations moving at varying speeds. For example, the animation of a jumping character would have objects in frames that are evenly spaced during the part of the jump sequence that is moving at a constant rate. When the sequence begins to slow, the objects in the frames that would appear closer together. When the sequence speeds up, the objects in the frames would move farther apart. The basic concept is illustrated in Figure 9-7.

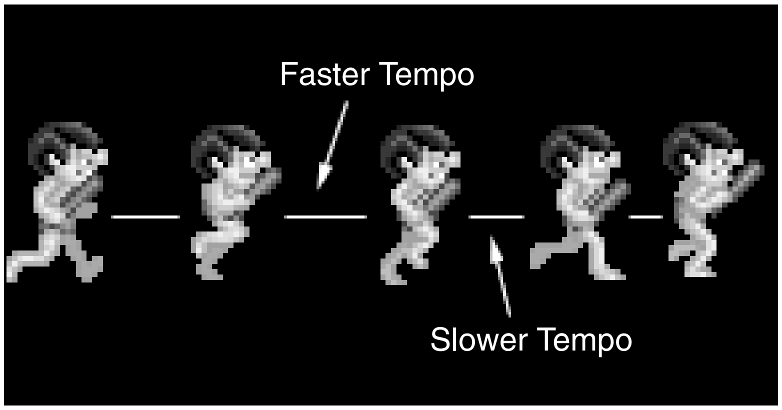


FIGURE 9-7: Tempo Example

We measure tempo in *frames per second (FPS)*, or the number of frames that can be displayed per second of time. The human eye can perceive movement (or the illusion of it) in as few as 12 frames per second. Generally speaking, the higher the frame rate (FPS), the smoother the animation. Therefore, it is preferable to display most forms of animation at a tempo that is greater than 12 frames per second.

Table 9-4 compares some of the more common animation frame rates for different forms of animation.

TABLE 9-4: Comparisons of Common Animation Frame Rates

Animation Type	*Frame Per Second (FPS)*
Computer video	15
Fast-action arcade game	30
Motion picture	24
Television	30

Unfortunately, FPS is not a universal constant when it comes to displaying animations on computers. Several factors, including the physical size, the number of frames involved, and the speed of the computer, can all adversely influence the rate at which animated sequences display. This is particularly true of the animation that appears in computer games, as they tend to really tax the systems that they are played on.

Table 9-5 provides some suggestions on the common frame rates for each type of arcade game.

TABLE 9-5: Common Arcade Game Frame Rates

Arcade Game Type	*Common Arcade Game Animation Frame Rates (FPS)*
Pong games	15-30
Maze/chase games	20-30
Puzzlers	9-15
Shooters	20-50
Platformers	20-30

Most game developers consider 15 FPS to be the minimum acceptable frame rate for fast-action arcade games and consider 20 or 30 FPS to be a desirable frame rate. Certain arcade game genres demand higher animation frame rates than others. This is because the fluidity of their animation enhances the overall user experience.

Sprites

Sprites are special graphic objects that can move independently of the screen background. Sprites are used in arcade games to represent spaceships, bombs, aliens, soldiers, and so on. In addition, they can be either animated or static and can also be used to represent a variety of fixed game objects such as treasure and power ups as well.

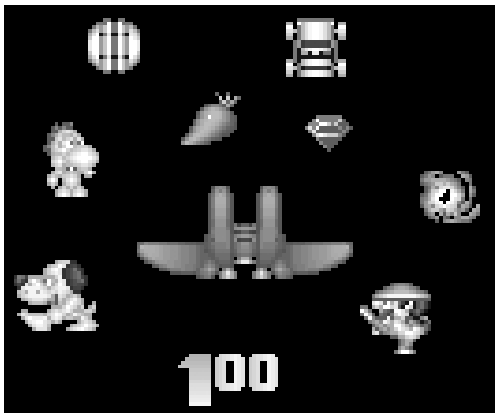


FIGURE 9-8: Sprite Examples

Sprite Properties

Sprites are used extensively by arcade games and have a number of interesting and distinct properties, including:

- Variable sizes and shapes
- Free range of movement
- Separate from background

Variable Sizes and Shapes

For the most part, sprites have no limits to either their size or shape. This being said, sprites can have rectangular, square, or even irregular shapes—it really doesn't matter. This versatility makes sprites useful for depicting virtually any type of object an arcade game may require. Sprites can also be of any size and they can change their size to respond to specific game events or actions as needed.

Free Range of Movement

Unlike other types of animated objects, sprites can move freely about the screen. This means that they are not restricted to displaying at specific areas of the screen. This characteristic makes sprite animations very effective in representing all types of moving game objects.

Separate from Background

Sprites exist as separate entities from the background of the screen. Sprites also support transparency, which, if you recall our discussion on transparency in Chapters 7 and 8, allows the background of an object to show through the foreground. This feature makes sprites particularly useful when used in games that have complex background screens since the contents of the background can be preserved as the sprite moves over it.

NOTE: Practically any graphic object can be used as a sprite. As a result, sprites can be created using most of the painting programs mentioned in Chapter 6.

Despite their unique advantages, sprites are among the most challenging aspects of creating arcade game graphics. This is because designing most sprites involves a complex two-step process. First, the sprite must be created just as any other graphic image. However, unlike most graphic objects, sprites tend to face more restrictions in terms of their size and use of color, which can complicate their design and increase the time required to create them. Then, after doing all of that work, the sprite needs to be animated, which, as you will soon see, is a very complicated process.

Grid Squares

As previously mentioned, the size of the sprite being animated can also impact the speed at which a sprite is animated. Smaller sprites will always animate faster than larger sprites, especially when there are lots of objects being displayed on the screen at once. This is because the computer has to manipulate less data with smaller sprites than it does with larger ones. Because of this, you should limit the size of your sprites whenever possible. One of the best ways to do this is to create your sprites in predefined size using a grid as a guide. Grids squares are miniature "screens" on which to draw sprites. As such, all grids have an *origin*, or a starting reference point. The origin helps us pinpoint the location of individual pixels within the grid when designing and editing individual sprite images. Like a graph, the origin of a grid square always starts at position (0,0), the position on the grid where X and Y are both equal to 0.

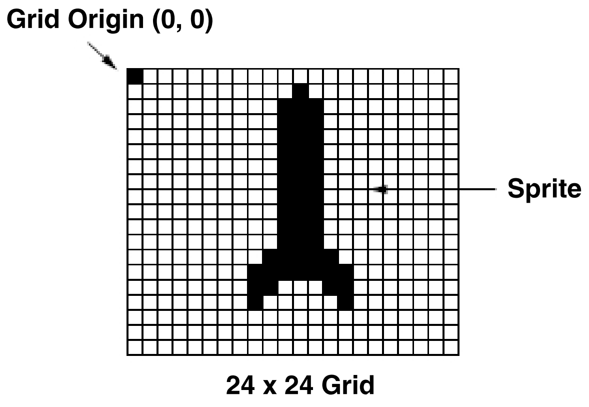


FIGURE 9-9: Grid Origin

Grid squares offer us a number of important advantages when creating sprites, including:

- Maintaining size consistency
- Assisting the animation process
- Optimizing sprites for implementation in games
- Optimizing sprites for screen performance

Maintaining Size Consistency

Grid squares are very useful for helping us to place constraints on the sizes of the sprites we create. This allows us to focus on packing as much detail as possible into the grid space that is available. As most sprite grids have visible borders that indicate their boundaries, this feature allows us to create sprites that are consistent and uniform in size. Keeping the sizes of your sprites consistent helps to improve their quality and better facilitates their incorporation into a game.

Assisting the Animation Process

Grid squares can also be quite useful for assisting us with the sprite animation process. This is due to the fact that grids allow us to arrange and organize sprites in a more consistent and predictable manner. This in turn makes them easier to manipulate than if they were haphazardly arranged on the screen. For example, you can use grids to arrange your sprites in the sequence you want an animation to appear. This makes it easier to work with your objects and improves your overall efficiency.

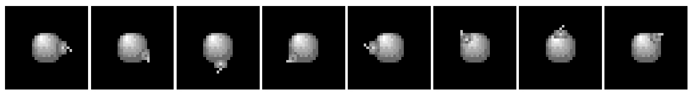


FIGURE 9-10: Example of Grid Containing an Animation Sequence

Optimizing Sprites for Implementation in Games

Because grid squares allow sprites to be easily arranged on-screen, they also make it possible to optimize the process of adding sprites to games. For example, many game development tools support the ability to import batches of sprites at one time. By arranging your sprite grids in a particular sequence and position inside a larger graphic image, you make it much easier to include them in a game, especially when dealing with large numbers of similarly sized objects. This can wind up saving you countless time, hassle, and effort during the course of a game project.

Optimizing Sprites for Screen Performance

Finally, grid squares offer programmers the opportunity to optimize their games around certain sprite sizes, which contributes to the overall screen performance of a game. You can find more information on this particular issue by referring to Chapter 2.

Table 9-6 highlights some of the more common sprite grid sizes used.

TABLE 9-6: Common Grid Square Sizes at Different Screen Resolutions

Screen Resolution	*Common Grid Sizes*
320x240	8x8, 16x16, 32x20, 32x32, 64x64, 96x64
640x480	16x16, 32x20, 32x32, 64x64, 96x64, 96x128, 128x128, 256x256
800x600	16x16, 32x20, 32x32, 64x64, 96x64, 96x128, 128x128, 256x256

NOTE: These sizes change in proportion to the screen resolution in which they are displayed. For example, an object animated at 16x16 at a resolution of 320x240 will appear as if it were created at 8x8 when shown at a resolution of 640x480. You can easily draw grid squares by using the Grid tool of your favorite painting program. This tool is described in more detail in Chapter 5.

You may have noticed that most of the common sprite grid square sizes are based on even multiples. This is intentional. In addition to helping with screen performance, evenly sized sprite grids also simplify the programming process because they allow for cleaner and more optimized math in programs. This being said, this doesn't actually mean that the sprites you design inside these grids have to be evenly sized. For example, a given grid square might be 32x32 but the sprite inside the grid square might actually measure 29x27.

Table 9-7 provides some examples of how these different grid square sizes might be used for different types of arcade game objects.

TABLE 9-7: Example Grid Square Sizes for Different Game Objects

Grid Square Size	*Comments*
8x8, 16x16	Useful for small objects such as bullets or missiles. Can also be used to represent on-screen text characters at lower screen resolutions (i.e., 320x200).
32x20, 32x32	Useful for objects such as spaceships, bonus items, icons, and other small on-screen objects in most screen resolutions.
64x64, 96x64, 128x128	Useful for larger spaceships and vehicles as well as most on-screen objects in most screen resolutions.
Greater than 128x128	Useful for very large objects, namely "boss" objects, or major characters that frequently appear at the end of game levels, etc.

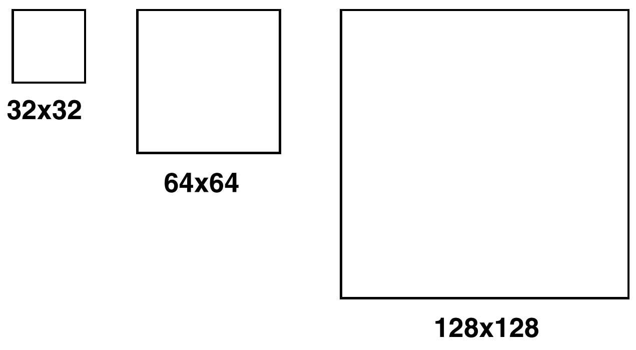


FIGURE 9-11: Comparison of Different Grid Square Sizes

Table 9-8 provides some suggestions for using sprite grid sizes for different types of arcade games.

TABLE 9-8: Suggestions for Using Grid Square Sizes in Different Arcade Game Genres

Grid Size	*Suggested Arcade Game Genre*
8x8, 16x16	Pong games, maze/chase, shooters
32x20, 32x32	Pong games, maze/chase, shooters
64x64, 96x64, 128x128	Pong games, maze/chase, puzzlers, shooters, platformers
Greater than 128x128	Shooters, platformers

Table 9-9 shows the grid square sizes that are most useful at different screen resolutions.

TABLE 9-9: Using Grid Square Sizes at Different Screen Resolutions

Grid Size	*Suggested Screen Resolution*
8x8, 16x16	320x200, 320x240, 640x480
32x20, 32x32	320x200, 320x240, 640x480, 800x600
64x64, 96x64, 128x128	320x200, 320x240, 640x480, 800x600
Greater than 128x128	640x480, 800x600

NOTE: The information presented in Tables 9-7, 9-8, and 9-9 is to be used as general guidelines only. You are certainly free to use grid sizes other than the ones mentioned here.

General Rules for Creating Grid Squares

There are a few items to consider before going to the trouble of designing your artwork using a specific grid square size. These issues include:

- **Programmer requirements**—In order to maximize screen performance, some games use sprites that are hard-coded to certain sizes. Therefore, never choose a particular grid square size to create your sprites without first consulting with your programmer! Otherwise, you're likely to create sprites that are incompatible with the game's animation code and will probably have to redo a large portion of your work.
- **Grid square size in relation to other objects**—During your initial graphics work, you may find that you need to make certain game objects larger or smaller to better fit the overall look and feel of the game. Therefore, always test the grid square size you choose before using it for all of your sprites. To do this, simply create a few key objects using the selected grid square size and see how they fit together. Place the objects side by side and in relation to the rest of the items in your game, i.e., backgrounds, status indicators, etc. After a few quick tests, it should become clear whether or not a particular grid square size will work for your game. Taking this extra step can save you a lot of extra time and effort later on.
- **Proper grid square scaling**—It helps if you use grid squares that are divisible by a power of two. Doing this has several advantages. First, it allows your sprites to be compatible with all common screen resolutions. Second, it facilitates their placement on the screen, as all common screen resolutions are also divisible by a power of two. Third and finally, doing this allows you to scale your sprites up or down to other sizes as the need arises with minimal loss in quality.

One last word about sprite grid sizes: be very careful when creating them! When the programmer specifies a grid size of 32x32, find out if the 32x32 dimensions include the grid border or just the contents of the grid cell. This detail is often overlooked and can result in game objects that do not fit together properly, such as background tiles.

Therefore, to be safe, always make your grids one pixel larger than what is specified in both the X- and Y-axes. For example, when tasked with making objects that are 40x40 in size, create a grid that is 41x41, as this will account for the grid's border.

Core Arcade Game Animation Primitives

Animated objects are at the heart of every arcade-style game. They represent the stylistic sequences that comprise everything from on-screen characters that walk, run, and jump to spaceships and special effects such as flashes and explosions. It's these objects that ultimately make arcade games engaging and appealing to those who play them. Yet, despite all of the outward differences each arcade game exhibits in terms of their looks, the animations that give them unique character all share a common set of *primitives*, or techniques of producing animated sequences. This is a little-known fact but an extremely important one. Once you understand how these arcade animation primitives work, you will have an important insight into how arcade game animations are designed and created.

The purpose of this section is to highlight these core animation primitives and explain both how they work and how to use them effectively in your own arcade-style game projects.

For the purposes of this book, these key animation primitives can be grouped into three general categories. These categories include:

- Major arcade game animation primitives
- Minor arcade game animation primitives
- Complex arcade game animation primitives

Major Arcade Game Animation Primitives

This category includes seven of the most basic animation primitives that are used in nearly every arcade game. The techniques described here are relatively simple in nature and are applicable to both character and mechanical objects of all types. They include:

- The cylindrical primitive
- The rotational primitive
- The disintegration primitive
- The color flash primitive
- The scissors primitive
- The growing primitive
- The shrinking primitive

The Cylindrical Primitive

This primitive is used in arcade games to represent the spinning motion of round, cylindrical objects. Although this doesn't sound like much, you'd be surprised. In arcade games, these objects can be used to represent a diverse and extensive range of elements including ship's hulls, buildings, missiles, robots, and even car wheels.

The cylindrical technique is among the easiest animation techniques to master because unlike most forms of animation, it doesn't require any dramatic changes to occur between frames to produce its intended effect. Rather, cylindrical animations rely on points or lines called *markers* that change gradually from one frame to the next as illustrated in Figure 9-12.

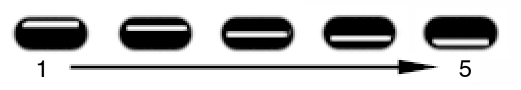


FIGURE 9-12: Cylindrical Animation Example

NOTE: Technically, this animation sequence can be completed in as few as four frames. However, the example in Figure 9-12 shows five in order to emphasize the full motion of a typical cylindrical effect.

When animated it will produce the illusion of the object rotating in place. Here's a quick breakdown of the motion that's taking place:

- **Frame 1:** The marker (the horizontal line) is positioned near the top of the object.
- **Frame 2:** The marker moves down slightly from the previous frame.
- **Frame 3:** The position of the marker moves to the center of the object. This provides an unmistakable visual clue that the object is starting to rotate since the marker has made a dramatic and visible positional change since frame 1.
- **Frame 4:** The marker moves down past the center. If you look carefully, you'll see that frame 2 and frame 4 are exact opposites of each other in terms of the position of the marker.
- **Frame 5:** The marker moves to the bottom of the object. At this point, a single rotation has been completed and the animation is ready to be cycled.

Creating effective cylindrical animations requires that you pay close attention to three things: color selection, proper positioning of the marker, and sequence length.

Because it doesn't rely on the broad or exaggerated changes used by the other forms of animation, the cylindrical primitive requires that you pick suitable colors to support the effect. These colors should be high contrast shades with the marker color being the most prominent of them. Making the marker brighter than the rest of the object serves two important purposes. First, it establishes the point of change on the object. This cues the user's eyes to follow the object as it is animated. Second, it serves as a highlight that reinforces the object's illusion of roundness.

The position of the marker can make or break a cylindrical animation. The marker should always travel from one end of the object to the other in a smooth and predictable fashion. If it doesn't, the illusion of motion won't be properly established and the animation will fail. To ensure that the marker is always positioned correctly, move it in gradual increments as this will give you more control over its progression along the surface of the object and give you the opportunity to correct it during the design process. The correct positioning of the marker is one of the more difficult aspects of creating this type of animation. To help give you a better sense of how to do this, look at a real-world object such as a large coin. Turn the coin on its side and roll it in your fingers. Notice how the light moves along the edge of the coin. Move the marker in the same fashion and the animation will produce the desired result.

The effectiveness of cylindrical animations is also greatly influenced by the number of frames used to create the effect. To ensure that the animation is successful, plan on rendering the cylindrical animation using between three and ten frames. In my experience, seven works best, but more can be used without drawing out the effect too much. Never use less than three frames to represent any cylindrical animation since there won't be enough frames available to adequately show the flow of movement.

TABLE 9-10: Cylindrical Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Cylindrical animations should never have an uneven (non-linear) motion path. Cylindrical animations always have straight motion lines.
Motion angles	Motion angles are always straight.
Key-frames and in-betweens	Three to four key-frames with up to three in-betweens produce the smoothest and most effective cylindrical animation sequences.
Weight and gravity	These properties *may* influence the speed at which a cylindrical object rotates if it's large or heavy.
Flexibility	Does not apply and has no effect.
Secondary actions	Has no effect as all parts of the object move at the same time during cylindrical animations.
Cycles and loops	Cycles are used extensively in cylindrical rotation sequences. All cylindrical animations loop; otherwise, the effect won't seem continuous.
Tempo	Used extensively to adjust the speed at which the cylindrical action occurs. Be careful not to move objects too quickly when performing cylindrical animations. Doing so has a tendency to ruin the effect.

The Rotational Primitive

The rotational animation primitive is often used in arcade games to describe a variety of rotating object movements. Although it's often confused with cylindrical-style animation, it's really a unique technique unto itself. In arcade games, rotational animation is used to represent everything from rotating gun turrets to spinning asteroids, making it a powerful and versatile technique.

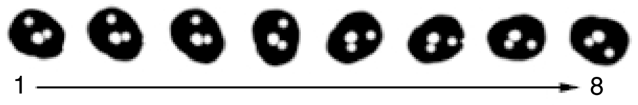


FIGURE 9-13: Rotational Animation Example

The rotational technique is popular because it's easy to implement. Basically, it works this way: an object is rotated in variable increments using a 360-degree scale. The object completes a single rotation when it progresses from 0 to 360 degrees over the course of successive frames.

Rotational animations can move either clockwise or counterclockwise. There's also a direct relationship between the smoothness of the animation and number of degree increments each frame represents. For example, an object such as a gun turret can complete a full rotation in as little as four frames if each frame represents a 90-degree rotational increment. At the extreme end, a rotating object can require as many as 360 frames if each frame uses only a 1-degree rotational increment.

Refer to Table 9-11 for some suggestions on how to handle common rotating objects in arcade-style games.

TABLE 9-11: Common Arcade Game Rotational Object Suggestions

Arcade Game Object	*Degree Increments per Frame*	*Total Frames Required*	*Comments*
Asteroids/meteors (coarse)	45°	8	Minimum required to produce convincing animation.
Asteroids/meteors (smooth)	225°	16	Sufficient to render convincing animation.
Gun turrets (coarse)	90°	4	Minimum required to produce convincing animation.
Gun turrets (smooth)	45°	8	Sufficient to render convincing animation.
Spinning objects (coarse)	90°	4	Minimum required to produce convincing animation.
Spinning objects (coarse)	45°	8	Sufficient to render convincing animation.

Arcade Game Object	*Degree Increments per Frame*	*Total Frames Required*	*Comments*
Vehicle/character facings (coarse)	90°	4	Minimum required to produce convincing animation.
Vehicle/character facings (smooth)	45°	8	Sufficient to render convincing animation.

TABLE 9-12: Rotational Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Typically, rotational animations have straight motion lines, but there will be some waviness depending on how smoothly the object is rotated.
Motion angles	Motion angles are almost uniformly straight. Rotational animations seldom have uneven motion angles.
Key-frames and in-betweens	The number varies depending on the amount of smoothness you want to achieve. Anything between two and four key-frames is effective for this type of animation.
Weight and gravity	These properties may influence the speed at which an object rotates if it's large or heavy but has little effect on the animation otherwise.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Cycles are used extensively in rotational animation sequences. All rotational animations loop; otherwise, the effect won't seem continuous.
Tempo	Used extensively to adjust the speed at which the rotation action occurs. Very rapid tempos can help reinforce the notion of an object moving at a high speed. Similarly, very slow tempos can help give the impression of an object moving slowly.

NOTE: Rotational animations are the basis for other animation effects such as *motion blurs*. Motion blurs are effects used to depict the movement and passing of air that is disrupted by the motion of another object. For example, motion blurs occur when helicopter rotors move or when a fighter kicks or punches.

The Disintegration Primitive

The disintegration primitive is most often used in arcade games to remove objects from the screen. For example, when a character dies in a game, it gradually disintegrates and disappears so a fresh character can replace it. There are two factors to pay attention to when designing disintegration animations: the method of removal and the extent of the removal that occurs between each frame. Let's start with the removal method first. The three most common *removal methods*, or disintegration effects, are melting, dissolving, and color fading.

Table 9-13 identifies how each of these removal methods work and differ from each other.

TABLE 9-13: Common Object Removal Methods

Removal Method	*Effect Produced*	*How it Works*
Melting	Causes an object to appear as if it's melting, similar to a candle.	Gradually reduces the vertical area of an object and blends its pixels together to form an unidentifiable mess.
Dissolving	Causes an object to decay similarly to being dissolved by acid.	Gradually removes random patterns of pixels from the object over successive frames.
Color fading	Causes an object to slowly vanish.	Introduces gradual (or in some cases extreme) color changes to erase the object from the screen over time.

In order to remove an object effectively, once you select a removal method, it's imperative that you stick with the mechanics associated with the effect. In other words, if you choose to employ the dissolving method, don't use color fading as part of the removal process.

The example in Figure 9-14 uses the dissolving removal method.

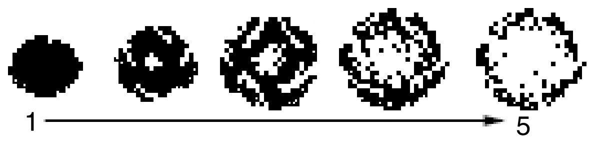


FIGURE 9-14: Dissolving Removal Example

Here's a breakdown of the animation sequence:

- **Frame 1:** This is an unmodified version of the original object.
- **Frame 2:** The object starts to break up. Care must be taken so that this effect occurs gradually but remains distinctly visible to the eye.
- **Frame 3:** The breakup effect continues. The integrity of the object continues to hold but large areas of its surface begin to vanish.
- **Frame 4:** There is further progression of the effect. Notice how large areas of the object are now gone.
- **Frame 5:** The object is now practically destroyed with only a few small areas of its original structure and shape now visible and intact.

As mentioned, how much of an object is removed during each frame of animation can influence the overall quality of the intended effect. For example, if you remove too much of an object's content too early in the animation sequence, the effect will look fake. Similarly, if you remove too little, the effect won't be as convincing. Planning the right amount and rate of removal for an object can be tricky. Therefore, to ensure positive results, try using what I call the *percentage method*.

Using this system, a fixed percentage of the object is removed on each successive animation frame. Not only does this method produce consistent results but it also will help you determine the maximum number of frames required by the animation. So, for example, if you set the removal percentage to 25 percent, 25 percent of the object will be removed per each frame of animation. This means that it will require a total of four frames of animation to completely remove the object from the screen. Since each removal technique requires a different number of frames to produce convincing animation, consult Table 9-14 for some general guidelines for using this method under different circumstances.

TABLE 9-14: Percentage Removal Method Guideline Suggestions

Selected Removal Method	*Estimated Percent Removed per Frame*	*Total Frames Required*
Melting (coarse)	25	4
Melting (smooth)	10	10
Dissolving (coarse)	25	4
Dissolving (smooth)	10	10
Color fade (coarse)	12.5*	8*
Color fade (smooth)	6.25*	16*

* Denotes that frames used should correspond to available palette entries to produce the best results.

NOTE: It's entirely possible to combine different removal methods to enhance the disintegration effect. However, because this can get messy fast, it's only recommended once you've mastered creating and using each of the different removal techniques individually.

TABLE 9-15: Disintegration Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Have no direct application to the disintegration action but are inherited from the original object and bound to its particular behavior (i.e., if a bird is flying, the disintegration animation will continue to fly as well and it will theoretically inherit the same wavy motion line).

Animation Property	*Comments*
Motion angles	Have no direct application to the disintegration action but are inherited from the original object and bound to its behavior.
Key-frames and in-betweens	Application varies. Depends on the desired smoothness of the disintegration action. Refer to Table 9-14 for more information.
Weight and gravity	Have no direct application to the disintegration action but are inherited from the original object and bound to its behavior.
Flexibility	Does not apply and has no effect.
Secondary actions	Have no direct application to the disintegration action but are inherited from the original object and bound to its behavior.
Cycles and loops	Rarely used since the purpose of disintegration animations is to remove an object from the screen in a graceful manner. Therefore, such sequences only move once and never cycle or loop.
Tempo	Used extensively to adjust the speed at which the disintegration action occurs. Correct tempo is a major factor in the success or failure of most disintegration-style animations. When in doubt, move your objects faster. Slow tempos, particularly when displaying explosion animations, can ruin the illusion produced by the effect.

The Color Flash Primitive

Color flashes are commonly used in arcade games to produce a flashing effect on or behind an object such as the sparkling of a jewel, the flicker of a torch, the flash of a light, or the pulse of a rocket motor. Color flashes work by applying a subtle (or dramatic) color change between each frame of the animation. This color change is usually limited to a fixed area within each frame and can range anywhere from a single pixel in size to an intricate, multipixel pattern. Regardless, when done properly, the color flash technique can produce an extremely effective "quick and dirty" effect that requires minimal time to create but adds a powerful sense of realism and character to a scene.

This being said, creating an effective color flash effect relies on four distinct factors: proper color selection, the size of the flash used, the number of frames involved, and the position of the flash on the object itself. In most situations, color flashes require you to use intense, contrasting colors. For example, to use a color flash to simulate a rocket exhaust at the back of a spaceship's engine, you should use shades of red with distinct contrast such as bright red, medium red, and dark red. When animated, these colors will exhibit the visible distinctions that will make the effect easier to see in the context of the overall object and game screen.

The size or radius of the color flash can also have a big effect on how convincing the effect looks when used on an object. A color flash that is too small will appear too subtle on-screen, whereas a color flash that is too large can ruin the effect and jeopardize the integrity of the object itself. For the best results, try to find a place in the middle of these extremes. Determining the right size for the color flash takes experience, but after creating just a few implementations, you'll begin to notice a pattern and will be able to judge the size properly.

Color flashes are generally meant to happen quickly. Therefore, their animations should be short and should not extend beyond a few frames. Color flashes that are between two and five frames in length are ideal. Anything less won't work and anything more can seem too drawn out. Thus, be careful in this regard and try to keep your sequence lengths relatively short.

Finally, the position of the color flash itself can make or break the intended effect. To ensure that the effect works as expected, always position the color flash logically. In other words, place the color flash where the user expects it to be. For example, jewels sparkle at the point where they reflect light. So, if you shade a jewel with the light source along the upper left-hand corner, the color flash should appear there and not in the middle or on the right-hand side. Like anything else, failing to take into account physical laws can diminish the effect that you're trying to achieve.

Figure 9-15 illustrates a complex form of the color flash as used in an animated logo sequence for a game.

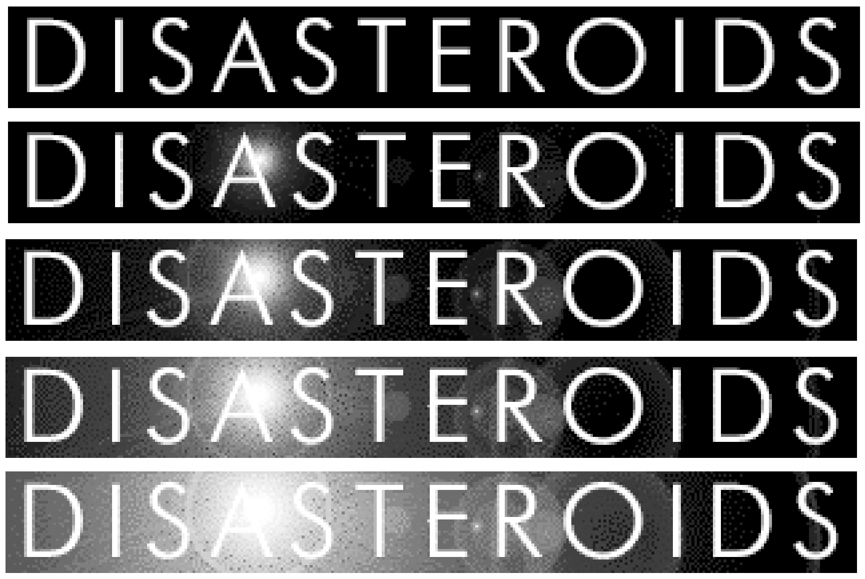


FIGURE 9-15: Example of the Color Flash Primitive

Here is a frame-by-frame synopsis of the effect in action:

- **Frame 1:** This is the original, unmodified logo.
- **Frame 2:** A subtle but noticeable light is placed behind the letter A.

- **Frame 3:** The light's intensity and flash radius increase by about 50%.
- **Frame 4:** This frame shows an increase in the light's size and radius by an additional 50% of what it was in frame 3.
- **Frame 5:** By the end of the sequence the light is several times larger and brighter than it was in frame 2. At this point, the animation should cycle back to frame 1 in order to restore the animation to its original state and create the sudden flashing effect that is the hallmark of this primitive.

TABLE 9-16: Color Flash Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Do not apply and have no effect.
Motion angles	Do not apply and have no effect.
Key-frames and in-betweens	Three to five key-frames and in-betweens are optimal. More can be used to smooth the effect but at the risk of appearing too drawn out.
Weight and gravity	Do not apply and have no effect.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Used frequently to produce the illusion of continuous action.
Tempo	Used extensively to adjust the speed at which the color flash occurs. Most color flash animations occur quickly; therefore, use a fast tempo whenever possible when creating animations of this type.

The Scissors Primitive

The scissors primitive is one of the most popular animation techniques used by arcade games and is used for effects that range from simple walking to creatures biting.

It's also one of the simplest animation techniques to create. The basic technique simulates the cutting action of a pair of scissors, hence the name. Using the scissors primitive, the animation starts in the closed position and gradually progresses to the open position by the end of the sequence. It works by taking advantage of the element of exaggerated motion. In other words, it relies on the introduction of vast changes from one frame to the next. This fools the eye into seeing the intended effect while using a minimum number of animation frames. Because of this, the scissors effect is ideal for animations that require use of as few frames as possible.

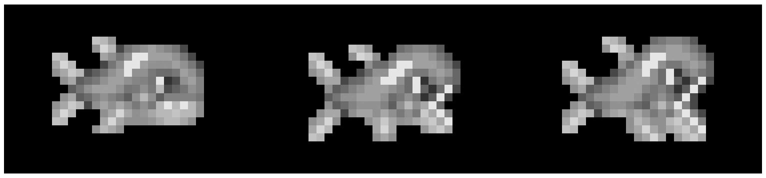


FIGURE 9-16: Example of the Scissors Primitive

Here's a breakdown of a typical scissors-based animation sequence:

- **Frame 1:** The first frame shows a fish with its mouth closed.
- **Frame 2:** The next frame shows the fish partially opening its mouth. This frame serves as the in-between between frame 1 (fully closed mouth) and frame 2 (fully open mouth) and makes the animation smoother and more realistic looking.
- **Frame 3:** The final frame of the sequence shows the fish with its mouth fully open. Should you want to make this a continuous motion, you could add cycling frames at this point of the animation sequence.

The effectiveness of scissors-type animation is entirely dependent on the number of animation frames used. Smoother scissors-like animation effects require more transitional frames while coarser scissors animations can get away with fewer transitional frames. However, scissors animations of between two and four frames are the most commonly used and encountered.

NOTE: Animations based on the scissors primitive can be horizontally or vertically oriented.

TABLE 9-17: Scissors Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Do not apply and have no effect.
Motion angles	Do not apply and have no effect.
Key-frames and in-betweens	Two key-frames at minimum. More frames will increase the smoothness of the animation. Three frames is the optimum.
Weight and gravity	Can influence the speed at which the animation occurs.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Cycles are frequently used in scissors animation sequences; however, their use depends on the complexity of the animation. Scissors animations make extensive use of looping to produce the illusion of continuous action.

Animation Property	*Comments*
Tempo	Used extensively to adjust the speed at which the scissors animation occurs. The object's tempo will vary according to the type of effect you're after.

The Growing Primitive

This primitive is commonly used in arcade games as a modifier for the other animation techniques described here. It essentially expands an object from one size to another such as during an explosion, when a character drinks a growth potion, or to simulate an object getting larger as it moves closer.

Figure 9-17 provides an example of this technique. Notice the progression of how the object changes its size.

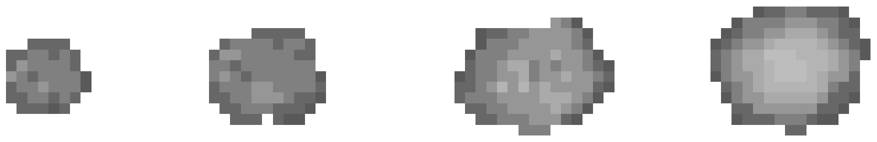


FIGURE 9-17: Growing Primitive Example

When using this primitive, it's important to pay close attention to the element of *scale*. Scale determines how large an object can become during the course of the animation. Always make sure that you use a constant scale. In general, it's good practice to use a scale based on a multiple of two. This ensures that the object will scale consistently. Otherwise, the object in question won't look right when it grows during the animation sequence.

TABLE 9-18: Growing Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Generally tend to be uneven as the growing object "grows."
Motion angles	Do not apply and have no effect.
Key-frames and in-betweens	This effect requires two to three key-frames to create effective growing sequences. Five to seven total frames is the optimum for most purposes.
Weight and gravity	Do not apply and have no effect.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Cycles tend not to apply to these types of animations due to the fact that object growth is incremental in nature and each frame requires a larger version of the object. Growth animations rarely loop due to this fact but can if the effect is warranted.

Animation Property	*Comments*
Tempo	Used extensively to adjust the speed at which the growing effect transpires. The object's tempo will vary according to the effect you're after.

The Shrinking Primitive

This is the opposite of the growing primitive. It, too, is a commonly used modifier for the other animation techniques described here. It essentially contracts an object from one size to another such as during an explosion, when a character drinks a shrinking potion, or to simulate an object getting smaller as it moves away from view.

When it comes to the element of scale, what applies to the growing primitive applies to the shrinking primitive as well.

TABLE 9-19: Shrinking Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Generally tend to be uneven as the growing object "shrinks."
Motion angles	Do not apply and have no effect.
Key-frames and in-betweens	Two key-frames is the minimum. More frames create smoother shrinking sequences. Five to seven frames is the optimum for most purposes.
Weight and gravity	Do not apply and have no effect.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Cycles tend not to apply to these types of animations due to the fact that object shrinking is incremental in nature and each frame requires a smaller version of the object. Shrinking animations rarely loop due to this fact but can if the effect is warranted.
Tempo	Used extensively to adjust the speed at which the shrinking effect transpires. The object's tempo will vary according to the type of effect you're after.

Minor Arcade Game Animation Primitives

This set of animation primitives is used in many types of arcade-style games but appears far less often than those described in the major animation primitives category. These techniques are applicable to both character and mechanical objects. They include:

- The piston primitive
- The squeeze primitive
- The swing primitive

- The slide primitive
- The open/close primitive
- The bounce primitive
- The stomp primitive

The Piston Primitive

Objects that use the piston primitive appear to pump up and down or from side to side when animated. This effect is usually seen in mechanical objects such as engines, machinery, or robots.

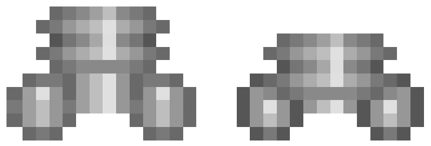


FIGURE 9-18: Piston Primitive Example

TABLE 9-20: Piston Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Piston-like animations tend to have non-straight motion lines.
Motion angles	Do not apply and have no effect.
Key-frames and in-betweens	Effective piston animations can be made with as few as two key-frames. More than eight frames is overkill for this type of effect.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in slower overall movement.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Piston animations make extensive use of both cycles and looping effects.
Tempo	Used extensively to adjust the speed at which the piston effect occurs. Piston animations usually occur quickly; therefore, use a fast tempo.

The Squeeze Primitive

Objects that use the squeeze primitive appear to compress themselves in a manner similar to an accordion when animated. This effect is usually seen in certain mechanical objects, such as spaceships and robots.

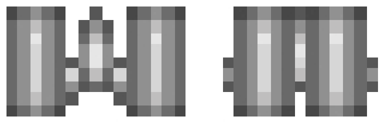


FIGURE 9-19: Squeeze Primitive Example

TABLE 9-21: Squeeze Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Squeeze animations almost always have constant and even motion lines.
Motion angles	Do not apply and have no effect.
Key-frames and in-betweens	Squeeze animations can be depicted in as few as two key-frames. Using more than four frames tends to minimize the effect as the squeeze primitive relies heavily on exaggeration.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in slower overall movement.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Squeezing animations make extensive use of both cycles and looping effects.
Tempo	Used extensively to adjust the speed at which the squeezing effect occurs. Squeeze animations usually occur quickly; therefore, use a fast tempo.

The Swing Primitive

Objects that use the swing primitive appear to swing like a pendulum either horizontally or vertically when animated. The swing primitive is actually a variation of the scissors primitive and is used by both mechanical and organic objects to represent movements from spaceship wings to chomping creatures.

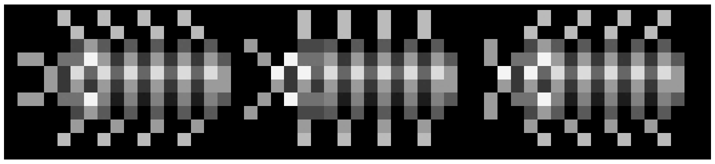


FIGURE 9-20: Swing Primitive Example

TABLE 9-22: Swing Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	They tend to have wavy motion lines that start out straight and sharply curve towards the center of the motion.
Motion angles	They tend to have very sharp motion angles
Key-frames and in-betweens	Swing animations can contain any number of key-frames. More key-frames will, of course, result in smoother swinging animation effects.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in slower overall swinging movement.

Animation Property	*Comments*
Flexibility	Does not apply and has no effect.
Secondary actions	Usually doesn't apply, but can in certain instances, particularly when animated walking objects can make use of secondary actions to enhance the drama of the effect.
Cycles and loops	Swinging animations make extensive use of both cycles and looping effects.
Tempo	Used extensively to adjust the speed at which the swinging effect occurs. The object's tempo will vary according to the effect you're after.

The Slide Primitive

The slide primitive is used to represent sliding and shuffling type movements. Such movements are frequently used to create simple walking and crawling animations with only a handful of frames.

The slide primitive works by taking advantage of excessive exaggerations. When done well, this has the effect of fooling the observer into thinking the object is walking or crawling even though no part of the object has left the ground.

Figure 9-21 demonstrates the sliding primitive in action. Notice how the character's arms and feet work in unison to give the impression that the character is sliding across a surface.

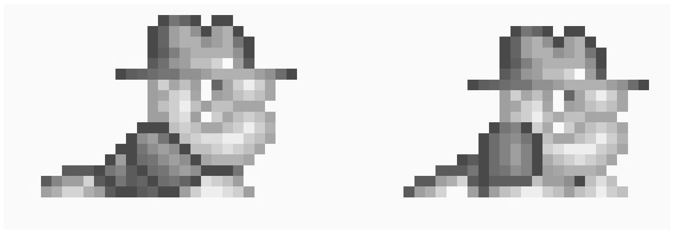


FIGURE 9-21: Slide Primitive Example

TABLE 9-23: Slide Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Sliding animations are almost exclusively straight and constant. However, occasionally you will encounter sliding animations that have uneven motion lines.
Motion angles	Tend to be very sharp for certain parts of the object being animated, i.e., legs and arms.
Key-frames and in-betweens	Sliding animations are extremely simple and usually only comprise two key-frames: object still and object sliding. Adding in-betweens will enhance the sliding motion and are encouraged.

Animation Property	*Comments*
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in a slower overall sliding movement.
Flexibility	Does not apply and has no effect.
Secondary actions	Occasionally applies to sliding objects, particularly during walking sequences.
Cycles and loops	Sliding animations make extensive use of both cycles and looping effects.
Tempo	Used extensively to adjust the speed at which the sliding movement occurs. Slide animations run more slowly than most other animation primitives; therefore, slow down the tempo when creating sliding effects.

The Open/Close Primitive

As the name implies, objects that use the open/close primitive have two states: open and closed. As such, this primitive is most commonly used to depict simple objects such as doors. However, this primitive can be used to produce emotion in detailed characters such as the blinking of an eye as illustrated by Figure 9-22.

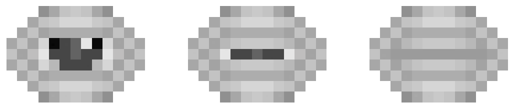


FIGURE 9-22: Open/Close Primitive Example

TABLE 9-24: Open/Close Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Do not apply and have no effect.
Motion angles	Do not apply and have no effect.
Key-frames and in-betweens	Almost all open/close animations require at least two key-frames. Adding additional frames can enhance the effect but isn't required.
Weight and gravity	Do not apply and have no effect.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Open/closing animations make extensive use of both cycles and looping effects.
Tempo	Used extensively to adjust the speed at which the open/close action occurs. The object's tempo will vary according to the type of effect you're after.

The Bounce Primitive

The bounce primitive is commonly used in arcade games on objects to simulate simple objects traveling or bouncing back and forth between two endpoints. It should not be confused with the element of gravity. This primitive is generally limited to mechanical objects such as computers and robots.

Figure 9-23 shows the bounce primitive in action. In this example, the white dot at the center of the object "bounces" back to its original position when looped.

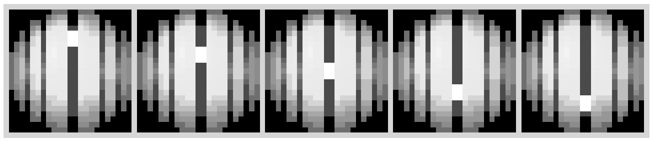


FIGURE 9-23: Bounce Primitive Example

NOTE: This primitive should not be confused with the cylindrical primitive as it is not intended to simulate the motion of an object spinning in place.

TABLE 9-25: Bounce Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Always have straight motion lines.
Motion angles	Always have straight motion angles.
Key-frames and in-betweens	Requires at least two to three key-frames to produce a relatively convincing effect. Adding more frames will improve the smoothness of the bouncing movement.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in a slower overall bouncing movement.
Flexibility	Does not apply and has no effect.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Bouncing animations are usually too simple to require cycles. However, bouncing animations make extensive use of looping effects.
Tempo	Used extensively to adjust the speed at which the bouncing movement occurs.

The Stomp Primitive

Objects that use the stomp primitive appear to flail from side to side much like a person stomping their foot. Because of this and the fact that the stomp primitive only has two states, up or down, it's used to depict a simple and exaggerated form of walking for characters, human and otherwise. In fact, alien invader type objects frequently use it.

Stomp-like animations are largely secondary actions since they typically only affect the feet or bottom of an object.

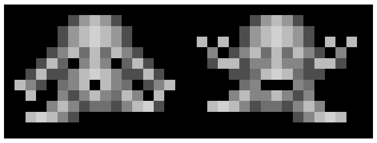


FIGURE 9-24: Stomp Primitive Example

TABLE 9-26: Stomp Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Have short and extremely wavy motion lines.
Motion angles	Have very sharp motion angles.
Key-frames and in-betweens	Requires at least two to three key-frames to produce a relatively convincing effect. Adding more frames will improve the smoothness of the bouncing movement.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in a slower overall stomping movement.
Flexibility	As all stomping animations deal with legs, care should be taken to ensure that the stomping movement is crisp.
Secondary actions	Do not apply and have no effect.
Cycles and loops	Stomping animations make extensive use of both cycles and looping effects.
Tempo	Used extensively to adjust the speed at which the stomping movement occurs. Stomping animations tend to run slower than most other animation primitives; therefore, slow down the tempo when creating these type of effects.

Complex Arcade Game Animation Primitives

This category of animation primitives encompasses the fundamental character and creature animation techniques that are used in platform-style games, regardless of their particular style or theme.

- The slinking primitive
- The flying primitive
- The walking primitive

- The running primitive (humans)
- The running primitive (animals)
- The jumping primitive
- The crawling primitive

NOTE: Several of the figures used in this section of the chapter are based on observations and computer drawings made from material presented in Eadweard Muybridge's books, *The Human Figure in Motion* and *Animals in Motion*. Both of these books do an excellent job of breaking down the complex movements of both humans and animals into easy-to-digest pieces. These books are excellent resources for anyone interested in creating more realistic arcade game animation.

The Slinking Primitive

Slinking is a form of locomotion that certain "lower" animals such as snakes and worms use. Therefore, it's commonly used in arcade-style games that feature such animals.

The basic slinking motion incorporates elements of the squeezing primitive in that these creatures move as a result of the momentum produced as their bodies squeeze and straighten. Slinking movements utilize a great deal of exaggeration in order to produce the best impression of motion with as few frames as possible.

Figure 9-25 demonstrates how a cartoon snake would move using a slinking motion.

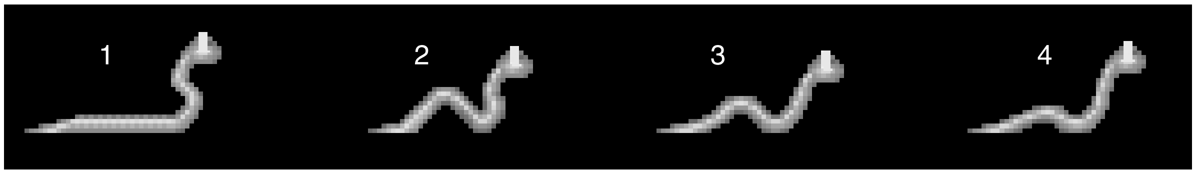


FIGURE 9-25: Slinking Example

Here's a breakdown of how this particular slinking animation works:

- **Frame 1:** Shows the snake with its body straight and neck and head curled and braced for movement.
- **Frame 2:** Shows the progression of the movement as the snake's body curls upwards as if it's pushing the rest of the body forward. Frame 2 is also an excellent example of secondary action as the snake's head and tail also move, albeit at different points.

- **Frame 3:** Here we see the snake's body beginning to flatten. At the same time, the snake's head and neck lurch forward. This further reinforces the notion that the snake is moving by the sheer force of momentum.
- **Frame 4:** Here, the snake's body is nearly completely flat and its head and neck are in a similar position to how they were originally in frame 1. At this point, you would cycle the animation to continue the flow of movement.

TABLE 9-27: Slinking Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Always have slightly wavy motion lines.
Motion angles	Always have straight motion angles.
Key-frames and in-betweens	All four frames qualify as key-frames when using this type of primitive. Of course, smoother animation can be achieved by adding corresponding in-betweens for each key-frame used.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in a slower overall slinking movement.
Flexibility	Although snakes, worms, and snails don't have joints or backbones, you should pay attention to flexibility when applying slinking movements, as these will enhance the naturalness of the movement.
Secondary actions	Secondary actions occur very frequently in slinking animations. Pay close attention to heads and tails in addition to the main part of the object's body as it moves.
Cycles and loops	Depending on their complexity, slinking animation sequences can make use of cycles. However, all slinking motions require loops to provide the illusion of continuous movement.
Tempo	Used extensively to adjust the speed at which the slinking movement occurs. Slinking animations run slower than most other animation primitives; therefore, slow down the tempo when creating slinking effects.

The Flying Primitive

Animating the motion of birds and insects can be a fairly complex business that requires a lot of time and study on how creatures fly in order to do properly. Birds, and all flying creatures for that matter, move their wings from the down position to the up position and vice versa. This motion is then repeated, or cycled, to complete the sequence. It takes flying creatures several steps to transition the movement of their wings from these states.

Under most circumstances, it can take as many as 12 frames to create a realistic flying animation. However, by breaking the basic flying motion into its most exaggerated components, you can extract the key-frames and produce effective, if not somewhat less realistic, flying animations in as few as five frames.

NOTE: It's actually quite possible to produce passable flying animations with as few as two key-frames (up and down). However, you will need to make sure that you compensate for the lack of key-frames by using extensive exaggeration between the two frames and by using the proper tempo.

When studying a bird's flight, you should take careful note of motion path, motion angles, tempo, and secondary actions of the wings and body. Failing to do so can cause you to produce animations that are inaccurate and unconvincing.

To get a better idea of how the flying process works, let's look at a simplified example. Figure 9-26 shows a simplified flying sequence rendered in just five frames.

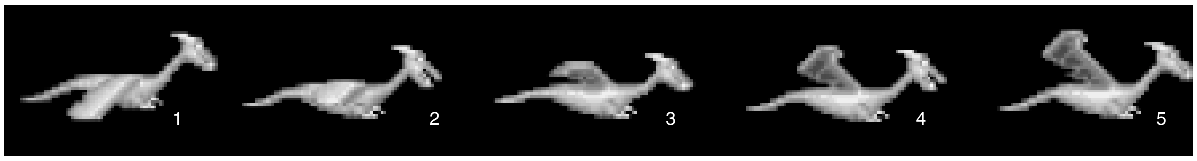


FIGURE 9-26: Simplified Flying Sequence

Here is a breakdown of the simplified flying sequence shown in Figure 9-26:

- **Frame 1:** The sequence begins with the bird's wings in the full down position. In this frame, the movement of the wings starts upward. The secondary action occurs at the head and tail with the head being fully raised and the tail pointing down.
- **Frame 2:** The wings are now level as if gliding. Here, the head begins to move down and the tail begins to level out. This produces an effect that is consistent with the flow of movement and cues the observer into believing the authenticity of the movement. The movement of the bird's head and tail between frames also produces a motion line consistent with flight. Since the exertion of movement and air turbulence both act against the bird, there's no way that it would have a perfectly straight motion line in the real world. Therefore, you wouldn't expect to have a straight motion line when creating its animation.
- **Frame 3:** Here the wings start to rise. The bird's head lowers farther and its tail begins to straighten out. Do you notice how the concept of the motion angle comes in play? The lowering of the head and leveling of the tail serve to visually emphasize the bird's acceleration as it starts to gain lift.
- **Frame 4:** The wings are nearing the completion of their upward movement. The tail and head begin to repeat their upward motion.

- **Frame 5:** The wings are now in a full upright position. At this stage, you could cycle the animation in reverse to restart the sequence and keep the sense of motion constant.

NOTE: You can start simplified flying animation sequences in either the up or the down state. It doesn't really matter as long as there is a beginning and an ending to the sequence.

Figure 9-27 represents a complex flying sequence. This is an exact frame-by-frame breakdown of how a bird really flies. If you compare it with Figure 9-26, you'll probably notice a number of similarities between the key-frames, the shape of the motion path, and the motion angles. For the most part, Figure 9-27 is identical to Figure 9-26 but it has seven more frames, or in-betweens, added in order to produce a smoother-looking animation sequence.

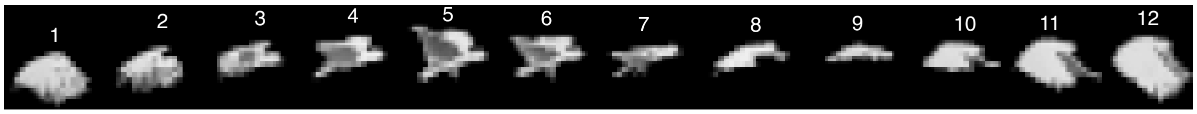


FIGURE 9-27: Complex Flying Sequence

Here's a breakdown of the complex flying sequence shown in Figure 9-26:

- **Frame 1:** The first frame starts with the bird's wings in the down position.
- **Frame 2:** This frame has the bird's wing and body slowing rising upwards.
- **Frame 3:** The third frame shows the bird's wing and body leveling out as if it's gliding.
- **Frame 4:** This frame shows the bird's tail drooping down and head and wings rising.
- **Frame 5:** Here, the bird's wings reach their uppermost point while its tail continues to move down. Notice how the first five frames show the unevenness of the bird's motion path.
- **Frame 6:** The bird's wings slowly move downwards. Its tail has now reached its lowest position in order to aid lift.
- **Frames 7 and 8:** These frames show the bird's wings moving down even farther.
- **Frame 9:** In this frame, the bird's body, tail, and wings are completely straight and level. Here, the bird's motion line also begins to straighten.
- **Frame 10:** The wings continue their downward progression.
- **Frames 11 and 12:** The wings once again complete their downward movement until they are fully extended. At this point, you could add cycles to keep the flow of motion constant.

As mentioned, it's very important not to neglect tempo when creating flying animations. Different birds fly at different speeds. For example, insects and hummingbirds tend to flap their wings at very high speeds, whereas most birds tend to flap their wings more slowly.

You should also remember to consider the effects of weight and gravity of the flying creature. For example, smaller birds and insects will tend to have very uneven motion lines because they flutter as they fly, but larger birds don't.

TABLE 9-28: Flying Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Always have wavy motion lines. Certain objects, namely complex bird and butterfly animation sequences, will have very wavy motion lines.
Motion angles	Always have straight motion angles.
Key-frames and in-betweens	Requires at least two key-frames. More frames will result in smoother flying sequences. In Figure 9-26, frames 1, 3, and 5 are key-frames while in Figure 9-27, frames 1, 5, 7, 9, and 12 are key-frames.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will result in a slower overall flying movement.
Flexibility	Flexibility should be emphasized around certain object parts such as the head, neck, and wings.
Secondary actions	Secondary actions occur very frequently in flying animations. Pay close attention to heads and tails in addition to the main part of the object's body as it moves.
Cycles and loops	Cycles are used extensively in all flying animation sequences. All flying animations make use of loops to provide the illusion of continuous and realistic flight.
Tempo	Used extensively to adjust the speed at which the flying movement occurs. Different animals fly at different speeds. For example, insects move their wings faster than birds. Along the same lines, smaller birds tend to move their wings faster than larger birds. Make sure you account for this and apply tempo properly.

NOTE: There is a direct relationship between the number of frames present in a flying animation sequence and the speed at which it moves. Slowly moving objects will require more frames than faster moving objects due to the way our eyes discern movement.

The Walking Primitive

Walking is used in almost every type of arcade game that involves humanoid characters and is particularly important for platform games. Unfortunately, walking is also one of the more difficult types of character actions to animate, especially for beginners. This is because walking is a complex motion. You see, walking involves multiple body parts such as the head, arms, and body, as well as the legs. However, the process becomes much easier if you break the walking process down into smaller pieces by focusing on animating each body part that is affected by the movement individually. Thus, walking is also an excellent way to sharpen your skills in creating secondary actions.

However, in order to do this, we need to review the different components of the walking process:

- **Step 1: The legs**—Walking always starts off with the legs. One leg grips the ground and pulls the other one forward. This essentially produces a propelling type of movement. When creating a walking sequence, always concentrate on the legs first.
- **Step 2: The arms**—The arms swing back and forth along with the motion of the legs but in the opposite order, i.e., as the leg on one side moves forward, the arm on that side moves back and vice versa.
- **Step 3: The head**—Factor in how the head moves along with the rest of the walking motion. In the real world, the head bounces slightly up and down as the positions of both legs change and the weight of the body shifts.

Simple walking can be achieved with only two key-frames as shown in Figures 9-28 and 9-29. One frame has the object standing still while the other frame has the legs of object spread widely apart. Also notice the use of a modified and heavily exaggerated form of the scissors primitive and the addition of secondary action subtleties such as arm and head movement. This enhances the effectiveness of the walk despite the small number of frames used to depict it.

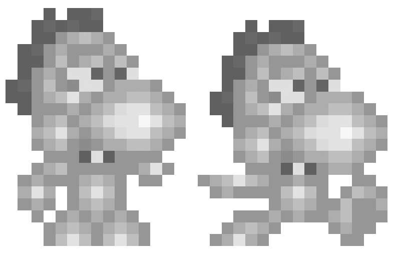


FIGURE 9-28: Basic Walking Example #1

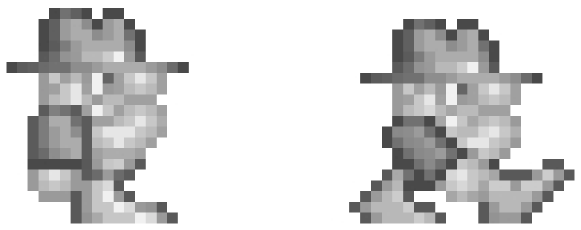


FIGURE 9-29: Basic Walking Example #2

Complex walking needs many more key-frames to produce a convincing animation sequence, however. Figure 9-30 provides an example of the complex walking sequence. As you can see, a realistic walking sequences requires as many as 11 frames to complete the illusion of movement.

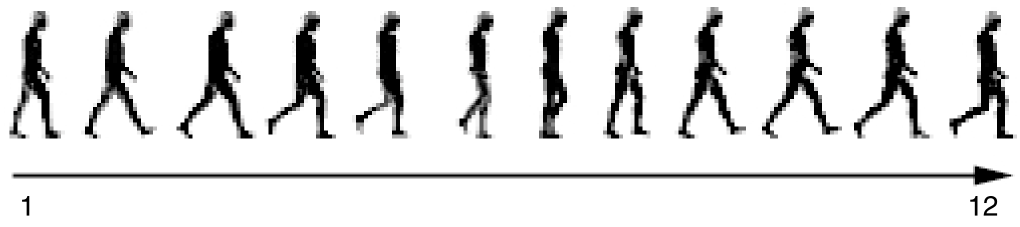


FIGURE 9-30: Complex Walking Example

Here's a breakdown of how a complex walking animation is constructed:

- **Frame 1:** This frame shows the character leading with the right leg. The right leg is actually in the process of moving backward but this won't become evident until later on in the animation sequence. This leg moves forward with the heel of the foot touching the ground and the toe and sole of the foot off the ground. The right arm is hanging straight down and the left arm is positioned forward while bent slightly at the elbow. As the animation progresses, the left arm will eventually move backward while the right arm moves forward.
- **Frame 2:** In this frame, the right leg extends forward. Meanwhile, the left leg begins to move backward in order to maintain support and provide the body with a stable platform. The right arm begins to move slowly backward to help counterbalance the general motion of the body while the left arm moves forward. The position of the character's head drops slightly as the weight of the body shifts and the back bends due to the change in the positioning of the legs.
- **Frame 3:** This frame has the right leg slightly bent at the knee. The foot is now largely flat with both the heel and toes nearly level. This is the point where the legs first begin to grip the ground. The rear leg now bends at the knee and its heel is lifted off the ground with the toes flattened. The right arm continues to move backward as the left arm moves slowly forward. The head now returns to its original position due to the new shift of body weight.
- **Frame 4:** In this frame, the right leg is now fully bent with the toes and heel now completely flat against the ground. The rear leg is still bent and moves off the ground, touching only at the toes. Both arms continue their movements as per frame 3. The position of the head is largely unchanged.
- **Frame 5:** This frame is a slight variation of frame 4 except that the right leg now begins to reverse its movement and starts to move backward. At the same time, the left leg is completely off the ground but moves forward. The right arm now moves forward in a counterbalancing action. The left arm draws back. The position of the head is unchanged, however.
- **Frame 6:** In this frame, the right leg is largely straight but continues to move backward. The left leg, still bent at the knee, moves forward to the point where it almost lines up with and begins to pass the right leg. The right arm

moves forward slightly while the left arm moves back slightly. The position of the head drops once again due to the shift in body weight.

- **Frame 7:** This frame demonstrates what is known as the *passing position* of the walk sequence. This is when one leg passes the position of the other leg. In this frame, the right leg is almost completely straight. Because of this, the character's back straightens and the head returns to its normal positioning. At the same time, the left leg passes in front of the right leg, although it's still bent and slightly off the ground. The right arm continues forward while the left arm continues backward.
- **Frame 8:** This frame shows the right leg starting to move backward slightly while the left leg continues to move forward. The right arm is now fully in front of the character's torso while the left arm is moving backward in small increments. The position of the head is unchanged from the previous frame.
- **Frame 9:** In this frame, the right leg is moving backward with the heel off the ground and is only stabilized at the foot by the toes. The left leg is nearing the completion of its forward movement. The right arm is nearing completion of its forward motion while the left arm continues its slow backward movement. The head is slightly dropped from the previous frame.
- **Frame 10:** This frame demonstrates the heel to toe part of the walk stride. In this frame, both legs are at their maximum distance from each other. In addition, only the toe of the foot stabilizes the right leg. The left leg has completed its forward movement. The right arm has completed its forward motion while the left arm has completed its movement backward. The head's position remains stable and largely unchanged.
- **Frame 11:** This frame shows the right foot positioned back. The left leg has locked out and the left foot lies flat against the ground. The right arm begins to reverse its movement and move backward. The left arm starts to reverse its motion and move forward. The head's position dips slightly due to the shifting in weight across the body.
- **Frame 12:** This is the final segment of the animation sequence. The right foot now begins its sweep forward while the left leg begins its sweep backward. The right arm continues to move backward while the left arm moves forward. The head returns to its normal position. You can create a very fluid walking sequence by cycling back to the first frame of the animation and then looping it.

Of all of the actions described in this section of the chapter, it's the legs that are the most difficult to visualize and animate. Therefore, use Figures 9-31 and 9-32 as "cheats" to help you break down this complex movement.

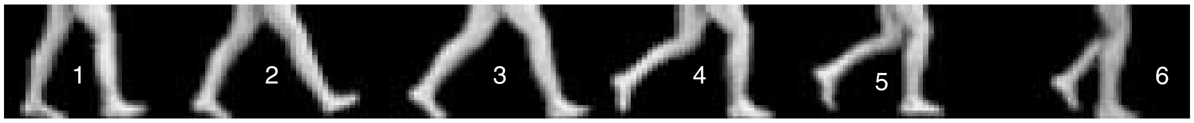


FIGURE 9-31: Walking Leg Movements (Part 1)

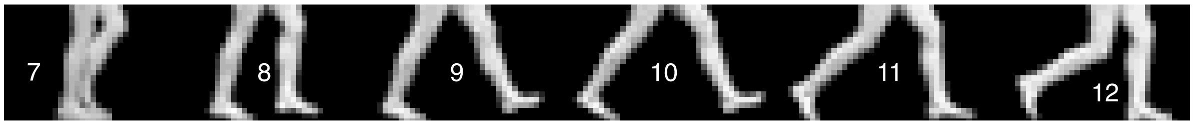


FIGURE 9-32: Walking Leg Movements (Part 2)

NOTE: There is a direct relationship between the number of frames present in a walking animation sequence and the speed at which it moves. Slowly moving objects will require more frames than faster moving objects due to the way our eyes discern movement.

TABLE 9-29: Walking Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Always have motion lines that are slightly wavy. Motion lines that are too wavy, particularly for complex animations, are probably too exaggerated and won't look convincing.
Motion angles	Have largely straight motion angles.
Key-frames and in-betweens	Requires at least two key-frames in simple walking sequences. As always, more frames will result in smoother walking sequences. In the complex walking sequence in Figure 9-30, the key-frames are frames 1, 3, 5, 7, 9, and 11.
Weight and gravity	Both of these can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will require heavier steps and result in slower overall walking movements and shorter exaggerations between frames.
Flexibility	Flexibility should be emphasized around the arms and legs. Depending on the size and the complexity of the object being animated, you might want to emphasize flexibility in the feet as well.
Secondary actions	Secondary actions occur extremely frequently during walking animations. Pay especially close attention to the head of the character, as it will bounce up and down as the position of the legs and feet change. In addition, hair and clothing will often exhibit secondary actions. For example, hair might flow or bounce (depending on length and style) and clothing might trail behind the character as it picks up speed. Incidentally, adding secondary actions to your walking sequences is an excellent way of tricking the observer into thinking the character is moving in a more realistic fashion than it really is.

Animation Property	*Comments*
Cycles and loops	Cycles are used extensively in all walking animation sequences, particularly for complex ones. All walking animations also make use of loops in order to provide the illusion of continuous and realistic movement.
Tempo	Used extensively to adjust the speed at which the walking movement occurs. Walking is usually done at a relatively slow pace. Therefore, keep the tempo moderate and constant.

The Running Primitive (Humans)

Running actions are commonly found in platform-style arcade games. They serve two purposes: first, they can heighten the sense of realism by simulating the act of acceleration. As the player applies more force on their controls, the on-screen character increases speed. Second, running actions allow the on-screen character to traverse more ground within the game area than when merely walking.

From an animator's standpoint, most of what applies to creating walking sequences applies to running as well. The main difference between the two movements is that the element of exaggeration between frames and the positioning of body parts to represent the various secondary actions is increased for running objects.

There are other differences between walking and running that should be mentioned. This section highlights the most important ones.

- **The arms**—Running actions emphasize the arms and their movement much more than walking. Arm movements in walking tend to be gradual, while arm movements in running tend to be highly exaggerated as the arm acts as a lever to help the overall motion of the object. This means that you should draw the arms of any running object with greater separation from the body. As such, take advantage of the element of flexibility as much as possible.
- **The body**—Running actions cause an object to have highly visible motion angles. This is because the body bends forward as it picks up momentum and speed while it moves. You will need to reflect this change in your running animations and tilt the body when creating such sequences.
- **The legs**—Running actions cause the object to cover more area than it would when walking. This means that the strides the legs take during a run should be extended to accurately depict this effect.
- **The head**—Running actions cause more violent up and down motions due to the increase in speed and the more extensive and rapid shift in body weight. Therefore, the up and down motion of the head should be more frequent and exaggerated. This means that running actions use more pronounced secondary actions than walking sequences.

Figure 9-33 provides an example of a complex running sequence. As you can see, a realistic running sequence requires as many as 12 frames to complete the illusion of movement.

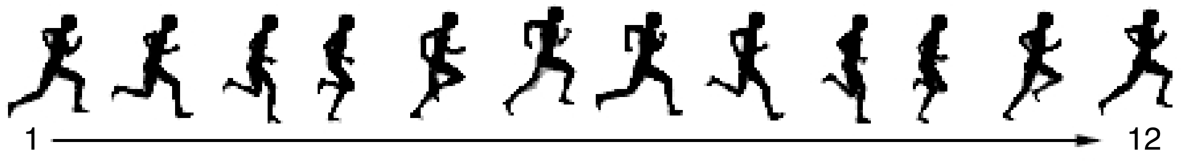


FIGURE 9-33: Running Primitive Example (Humans)

Here's a frame-by-frame synopsis of a typical, complex running action:

- **Frame 1:** The animation sequence starts with both legs off the ground with the right leg back and the left leg forward. Both legs are bent at the knees with the right leg partially bent and left leg fully bent. The right arm is forward with a 45-degree upward bend. The left arm has a 45-degree downward bend. The character's back is slightly arched forward and head is bent slightly forward.
- **Frame 2:** This frame shows both legs off the ground, although much closer to the ground than in frame 1. Both legs are still bent at the knees. This time, however, the right leg is bent back at a 90-degree angle. The right arm is now bent at an 85-degree angle as it travels downward and back. Meanwhile, the left arm lunges slowly forward. The character's back is still arched and the head has dropped down a bit more.
- **Frame 3:** In this frame, the right leg, now fully extended back begins the process of moving forward. The left leg is now very close to the ground. The right arm moves downward and the left arm moves forward. The character's head and back are hunched over as the character picks up speed.
- **Frame 4:** This frame demonstrates the *contact position* of the running movement, or the first point at which the runner's feet touch the ground. In this frame, the left foot touches the ground while the right leg, although still bent, is rapidly moving forward. The right arm is bent and quickly moving backward while the left arm is bent and moving forward. The position of the head and back are largely unchanged from the previous frame.
- **Frame 5:** This part of the animation sequence demonstrates the *push-off position* of the running movement or the point at which the runner's feet leave the ground in order to gain momentum in the stride. In this frame, the left leg prepares to leave the ground once again as it starts to push off the ground with the left foot. Meanwhile, the right leg enters the passing position with the left leg and lunges forward. The right arm is now at an almost complete 180-degree bend, as it swings backward. The left arm pushes forward and has a 45-degree bend. Both the head and back begin to straighten.

- **Frame 6:** This frame shows the character near full stride and once again leaving the ground. The right leg is extended almost completely forward. The right leg is almost fully bent and completely off the ground. The left leg is almost straight as it extends backward toward the ground. Both arms appear to pump furiously. The right arm is completely back and bent at a perfect 90-degree angle. The left arm is bent upward at a near perfect 45-degree angle. The head and back are almost completely straight.
- **Frame 7:** This frame is very similar to frame 6 as both legs remain completely off the ground. The right leg is now fully extended forward while the left leg continues to stretch backward. The right arm is still bent at a 90-degree angle and begins to move forward. The left arm is still at a 45-degree angle and starts to move back and downward. The head and back continue to straighten up.
- **Frame 8:** In this frame, the right leg is still off the ground but rapidly moving backward and down. The left leg is almost fully bent upward and is quickly moving forward and down. The right arm is moving forward and the left arm continues to move backward. In this frame, the head and neck are slowly moving forward again as the running motion again produces momentum.
- **Frame 9:** This frame has the right leg slightly bent and now touching the ground. The left leg is fully extended back. It won't move any farther back at this point, only forward. The right arm continues to move forward while the left arm moves back. It's interesting to note that both arms are almost even with each other. This is the only time during the entire sequence that such an event will occur. The character's head and back are once again starting to straighten.
- **Frame 10:** This frame is almost the direct opposite of frame 4. Here, the right leg is still on the ground but is about to spring off the ground. The left leg is also in the process of swinging forward. The right arm is now almost at a 90-degree angle as it moves forward. The left arm continues to move backward. Both the head and neck continue to straighten.
- **Frame 11:** This frame shows the beginning of the springing action of the running movement. The right leg extends as it moves backward. The left leg moves forward in a wide, exaggerated stride. Both arms are now at a 45-degree angle with the right arm moving up and forward and the left moving backward and upward. The head and back are now straight.
- **Frame 12:** This is the final frame of the animation sequence and it shows the character in a full running stride. The actions here are very similar to those in frame 1. You can create a very fluid running sequence by cycling back to the first frame of the animation and then looping it.

Use Figures 9-34 through 9-37 as "cheats" to help you break down this complex movement. Unlike walking, it's important that you capture all of the motion associated with this primitive, including the exaggeration of the arms and legs.

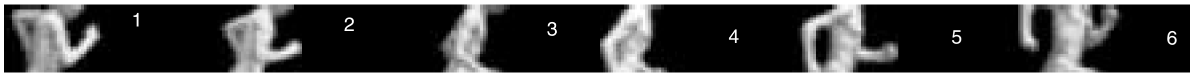


FIGURE 9-34: Running Movement—Arms (Part 1)

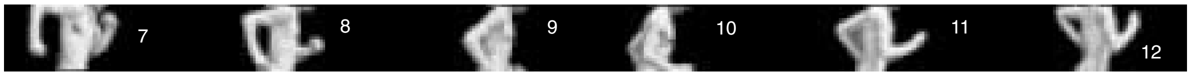


FIGURE 9-35: Running Movement—Arms (Part 2)

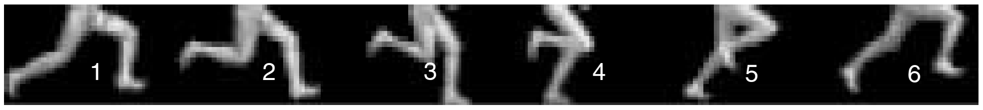


FIGURE 9-36: Running Movement—Legs (Part 1)

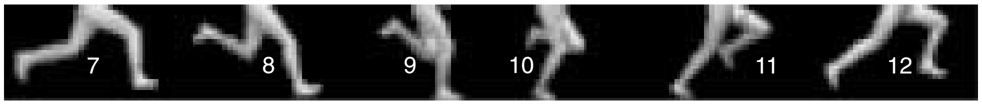


FIGURE 9-37: Running Movement—Legs (Part 2)

NOTE: Running actions are enhanced when you incorporate the element of anticipation. Anticipation helps to make runs look more realistic since it's not very convincing for full-speed running to occur from a walking or standard start. You can create the impression of anticipation by adding some additional transitional frames at the start of the running sequence. If this is too difficult or time-consuming, a simple alternative is to slow the tempo of the action during the first cycle of the animation.

TABLE 9-30: Running Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Running actions always have very wavy motion lines. Motion lines that are too straight will appear too stiff and rigid and won't look natural when animated.
Motion angles	Running sequences have very acute motion angles.
Key-frames and in-betweens	Requires at least two key-frames for simple running sequences. In complex running sequences, frames 2, 4, 6, 8, 10, and 12 are key-frames.
Weight and gravity	Both of these can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will require heavier steps and result in slower overall walking movements and shorter exaggerations between frames.

Animation Property	*Comments*
Flexibility	Flexibility should be emphasized around the arms and legs, particularly at the joints such as the knees and elbows. Depending on the size and the complexity of the object being animated, you might want to emphasize flexibility in the feet as well.
Secondary actions	Secondary actions occur very frequently in running animations. Pay close attention to the head of the character, as it will bounce up and down as the position of the legs and feet change. In addition, hair and clothing will often exhibit secondary actions. For example, hair might flow or bounce (depending on length and style) and clothing might trail behind the character as it picks up speed. For example, imagine a flowing cape or scarf. Incidentally, adding secondary actions to your running sequences is an excellent way of tricking the observer into thinking the character is moving in a more realistic fashion than it really is.
Cycles and loops	Cycles are used extensively in all running animation sequences, particularly for complex ones. All running animations also make use of loops in order to provide the illusion of continuous and realistic movement.
Tempo	Used extensively to adjust the speed at which the running movement occurs. Runs occur faster than walking or jumping sequences. Make sure that they have a faster tempo than the other primitives described in this chapter.

NOTE: You can add personality to your walking and running sequences by embellishing and exaggerating the various frames that make up the sequence. For example, you can simulate heavier characters (i.e., the effect of gravity) or double up frames to mimic the effect of a limp.

The Running Primitive (Animals)

Much of what has been discussed also applies to four-legged animals as well. Once you master the general theory behind creating walking and running sequences for humans, you should be able to handle most types of four-legged animals without too much trouble.

However, understand this: creating convincing movement for most four-legged animal characters is quite a bit more complex than doing so for human characters. Instead of having two legs to deal with, you now have four to manipulate. Thus, the best way to approach creating such animations is to create individual animation sequences for each set of legs. Although this works well for relatively simple four-legged actions, it will fail to produce convincing movement as the animation sequences get more complex. Therefore, I strongly recommend getting a copy of Eadweard Muybridge's excellent *Animals in Motion* as studying this book will give you important insights into how different four-legged animals move.

In any event, Figure 9-38 shows the basic action of a four-legged animal running. I decided to focus on the running action over walking because it is less complex and generic enough to represent a variety of four-legged animals including tigers, wolves, and even horses, albeit with somewhat less accuracy and realism.

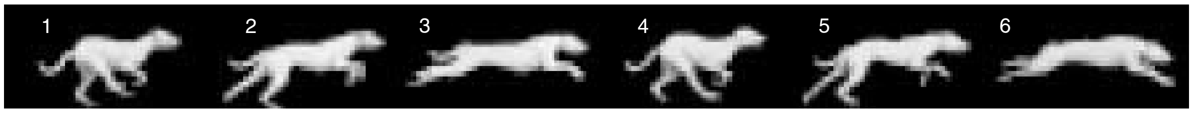


FIGURE 9-38: Running Primitive Example (Animals)

Here's a breakdown of this action:

- **Frame 1:** The first frame has the animal's back largely straight. The right forward leg is arched back while its right rear leg is positioned forward and the left rear leg is moving backward.
- **Frame 2:** This shows the animal's body beginning to stretch outward. Both front legs are bent and extending outward while the rear legs are stretching out and back. The rear legs are positioned near the ground while the front legs are moving away from it. The head and back are angled as a result of this position.
- **Frame 3:** This frame shows the animal's body completely level and outstretched. At this point, all four legs are off the ground. This is the full-stride position of the movement.
- **Frame 4:** This frame is very close in appearance to frame 1, the main exception being that the right rear leg is closer to the ground and the left rear leg is extended farther back than its position in the first frame.
- **Frame 5:** Frame 5 is almost identical to frame 2. The primary difference between the two frames is the order of the front legs. Here, the right front leg is extended farther out and the left front leg is positioned slightly farther back. The positioning of the rear legs is so close that you probably don't need to make any changes to their position.
- **Frame 6:** This is the final frame of the animation sequence. It shows the body of the animal outstretched with all four legs off the ground. Although also similar to the contents of frame 3, there is a major difference in the position of the head and back. In this frame, the head of the animal is pointing down while its back is arched sharply. All four legs are also positioned at more extreme positions than what is shown in frame 3.

TABLE 9-31: Running Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Running actions always have very wavy motion lines. Motion lines that are too straight will appear too stiff and rigid and won't look natural when animated.
Motion angles	Running sequences have very acute motion angles.
Key-frames and in-betweens	Requires at least two key-frames for simple running sequences. In complex running sequences, frames 1, 3, and 5 are key-frames.
Weight and gravity	Both of these can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will require heavier steps and result in slower overall walking movements and shorter exaggerations between frames.
Flexibility	Flexibility should be emphasized around the joints. Depending on the size and the complexity of the object being animated, you might want to emphasize flexibility in the feet as well.
Secondary actions	Secondary actions occur very frequently in animal running animations. Pay especially close attention to the head and tail of the animal. Animating these can greatly enhance and improve the realism of the sequence.
Cycles and loops	Cycles are used extensively in all running animation sequences, particularly for complex ones. All animal running animations also make use of loops in order to provide the illusion of continuous and realistic movement.
Tempo	Animals move at very fast speeds when running. Therefore, make sure you use an appropriately paced tempo to accurately represent this action.

The Jumping Primitive

Jumps are used in platform-style arcade games to help the on-screen character cover large sections of the game area in a single bound. They are also used to jump over obstacles and dodge other objects such as missiles and bullets.

There are many types of jumps but the most popular one is known as the *standing jump*. In this type of jump, the character jumps from a standing position. The jumping process has four parts: the *stand*, the *bend*, the *leap*, and the *landing*.

The stand is where the character begins the jumping sequence. The bend is where the character gains the strength and the position to make the jump. The leap is the actual jump itself. Finally, the landing is where the jump ends.

NOTE: Generally speaking, standing jumps have a shorter and more constant length than running jumps.

Figure 9-39 shows a simple running jump sequence. Here, there are only two frames needed: a standing frame (frame 1) and jumping frame (frame 2). Simple jumps work quite well for most purposes, particularly for unrealistic or cartoon-style characters. This is due to the exaggeration of movement that occurs between the two frames of the action.

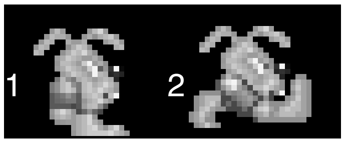


FIGURE 9-39: Simple Jumping Primitive Example

Figure 9-40 shows a complete, complex running jump sequence.

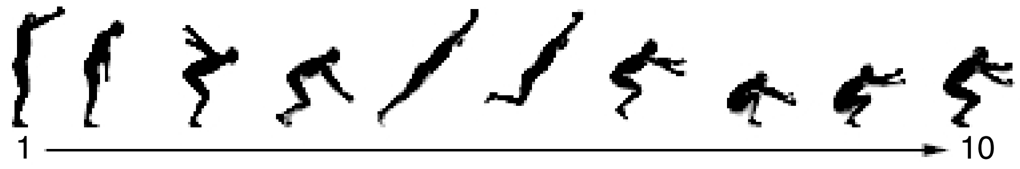


FIGURE 9-40: Complex Jumping Primitive Example

Here's a breakdown of each frame for this movement:

- **Frame 1:** In this first frame of the sequence, the character is standing. Both knees are bent and both arms are raised in anticipation of the jump.
- **Frame 2:** This frame shows the character starting to lean forward. Both legs are still bent and have moved since the last frame. The back and head are now bent forward and both arms are now straight down at the character's side.
- **Frame 3:** This frame shows the character at the start of the bend phase of the jump. Here, both legs are completely bent to support the back and head as they bend forward. Both arms make an exaggerated swing up and back to provide the jumper with additional pushing leverage.
- **Frame 4:** Frame 4 represents the start of the leap. Both legs are leaving the ground in a spring-like action while the arms rapidly swing forward in support. The head and body are bent completely forward at an 80-degree angle.
- **Frame 5:** This frame shows the character nearing the peak of the jump. The entire body of the character is at a 45-degree angle as it leaves the ground.
- **Frame 6:** This is the peak of the jump. Here, both legs push the character's body up and forward as they swing up and back. Both arms are straight and positioned above the character's head in support of this movement.
- **Frame 7:** Here we see the start of the landing. Although still off the ground, the character's legs swing forward. At the same time, the character's body, head, and arms lean sharply forward in anticipation of the landing.
- **Frame 8:** The character is nearing the point of landing. The entire body of the character curls in unison to absorb the impact of the landing. The arms, head, and back are bent forward while the legs start to bend backward.

- **Frame 9:** The character lands. The feet of both legs are now firmly on the ground while bent forward. The rest of the body is arched forward in order to minimize the effect of the impact.
- **Frame 10:** The jump sequence is completed. The character's body begins to rise and straighten as the force of the jump is absorbed and dissipated. Here, both knees remain bent, the back remains arched, and both arms continue their lunge forward. Unlike walking or running sequences, jumping animations are rarely cycled due to the nature of the action.

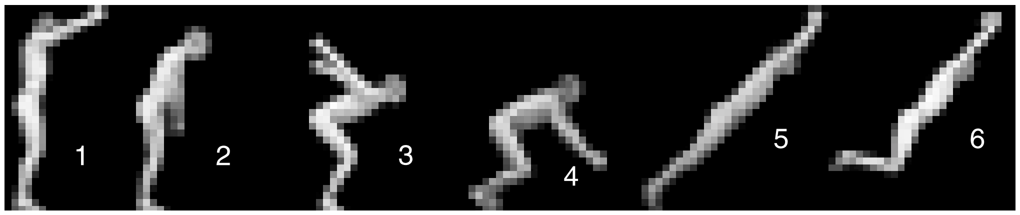


FIGURE 9-41: Complex Jump Sequence (Part 1)

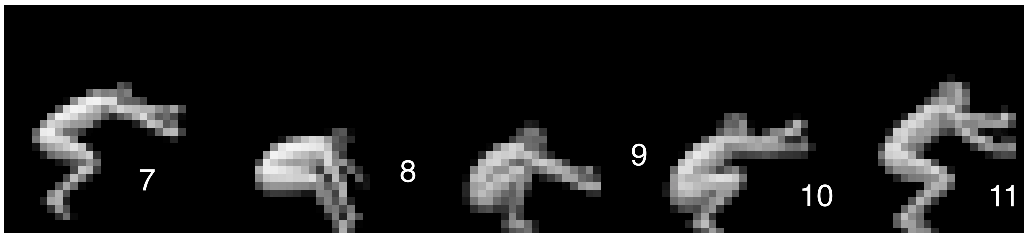


FIGURE 9-42: Complex Jump Sequence (Part 2)

TABLE 9-32: Jumping Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Jumping animations always have very wavy motion lines. Motion lines that are too straight will appear too stiff and rigid and won't look natural when animated.
Motion angles	Jumping animations have very acute motion angles.
Key-frames and in-betweens	Requires at least two key-frames in simple jumping sequences. As always, more frames will result in smoother sequences. In complex jumping sequences, the key-frames are frames 1, 3, 5, 7, 9, and 11.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will require heavier steps and result in slower overall jumping movements and shorter exaggerations between frames.
Flexibility	Flexibility should be emphasized around the arms and legs, particularly at the joints such as the knees and elbows. Depending on the size and the complexity of the object being animated, you might want to emphasize flexibility in the feet as well.

Animation Property	*Comments*
Secondary actions	Secondary actions occur very frequently in jumping animations. Pay close attention to the head of the character, as it will bounce up and down as the position of the legs and feet change. In addition, hair and clothing will often exhibit secondary actions. For example, hair might flow or bounce (depending on length and style) and clothing might trail behind the character as it picks up speed. For example, imagine a flowing cape or scarf. Incidentally, adding secondary actions to your jumping sequences is an excellent way of tricking the observer into thinking the character is moving in a more realistic fashion than it really is.
Cycles and loops	Since jumps are largely "one-off" actions, cycles and loops have little or no application for these actions.
Tempo	Used extensively to adjust the speed at which the jumping movement occurs. Jumps happen more slowly than most other character actions. Adjust the tempo of the animation accordingly.

The Crawling Primitive

Crawling is an action used by many platform-style games to help the on-screen characters fit into tight spaces and to avoid dangerous obstacles and objects while moving.

The basic act of crawling involves three steps: *bending*, *crouching*, and *moving*.

Bend is where the character begins the crawling sequence. Crouch is where the character assumes the proper position to begin crawling. Moving is the crawling process itself.

All crawling actions involve the *opposite action* of the limbs. In other words, the arms and legs move in opposite directions from each other. For example as the left arm moves backward, the left leg moves forward and as the right arm moves forward, the right leg moves backward. This action uses pushing and pulling to propel the body forward. During a crawling action, it is the legs that push and the arms that pull.

Figures 9-43 and 9-44 represent a typical complex crawling sequence.

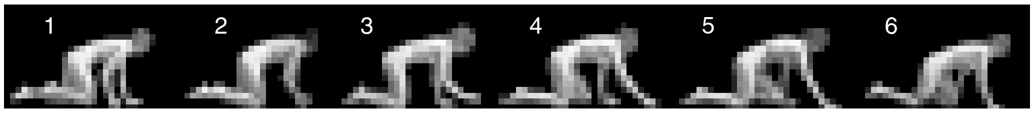


FIGURE 9-43: Crawling Primitive Example (Part 1)

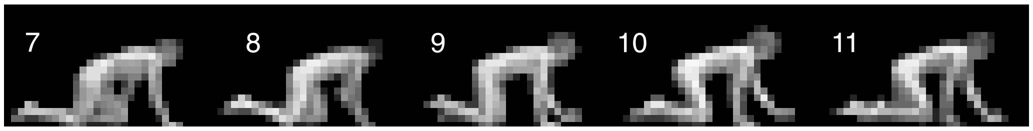


FIGURE 9-44: Crawling Primitive Example (Part 2)

As you can see, a complex crawling sequence can require as many as 11 frames of animation. Here's a frame-by-frame breakdown of the action:

- **Frame 1:** The first frame shows the character fully bent on all fours. The right leg is positioned forward; the right arm is positioned back. The left leg is shifted back and the left arm leads forward. The head is nearly level and facing the ground.
- **Frame 2:** This frame has the right arm moving forward and right leg moving backward. The left arm moves backward and the left leg moves forward. It's interesting to note that both legs are touching the ground at the knees with the calves suspended in the air. This is done in order to propel the body forward and gain momentum.
- **Frame 3:** This shows the progression of the right arm moving forward and up. It moves up in order to gain leverage for the forward motion of the crawl. The right leg is now at the midpoint of its motion and is closely aligned with the position of the left leg. The left leg continues to move forward while the left arm moves backward.
- **Frame 4:** In frame 4, the right arm stretches outward and forward as it attempts to pull the body of the character forward. The right leg shifts backward to aid in stabilizing the body. The left arm pushes back and the left leg moves forward.
- **Frame 5:** Here the right arm is fully extended forward while the right leg continues its backward motion. The left arm reaches back while the left leg aggressively shifts forward.
- **Frame 6:** Frame 6 is similar to frame 5, as all of the limbs continue their direction and force of movement.
- **Frame 7**: In this frame, the right arm is now beginning to move backward and the right leg is beginning to move forward. The left arm and leg start to move forward and backward, respectively.
- **Frame 8:** This frame shows the right arm continuing its backward motion and the right leg its forward movement. The left arm and leg continue their supporting motion as well.
- **Frame 9:** Here the left arm is now outstretched and duplicating the action that the right arm made in frame 4. The right arm and both legs help stabilize the body while this occurs.

- **Frame 10:** This frame has the right arm slowly moving back while the right leg thrusts forward. The left arm is now nearly fully extended, as it approaches the ground. The left leg continues to shift backward.
- **Frame 11:** This frame shows the right arm moving back and coming close to the right leg as it moves forward. The left arm is now completely extended and touching the ground. The left leg continues to shift backward. At this point, the animation would cycle back to frame 1 to complete the sequence and the continuous flow of motion.

NOTE: In most situations, you can also create simple, two-framed crawling actions. However, such animations require heavily exaggerated movements between frames and ample delineation between different parts of the figure in order to convince the observer that movement is actually occurring.

TABLE 9-33: Crawling Primitive Animation Property Summary

Animation Property	*Comments*
Motion lines	Crawling animations have an almost constant motion line. This is due in large part to the fact that the head and back rarely change position during the course of the crawling motion.
Motion angles	Crawling actions have relatively mild motion angles.
Key-frames and in-betweens	Requires at least two key-frames in simple crawling sequences as shown in Figure 9-21. As always, the presence of more frames will result in smoother crawling sequences. In complex crawling sequences, the key-frames are frames 1, 3, 5, 7, 9, and 11.
Weight and gravity	Can influence the speed at which the animation is displayed. For example, larger objects or denser gravity will require heavier steps and result in a slower overall crawling motion and a shorter exaggeration between frames.
Flexibility	Flexibility should be emphasized around the arms and legs, particularly at the joints such as the knees and elbows. Flexibility should be added to the hands and feet as they tend to bend slightly as they grip the ground in support of the crawling movement.
Secondary actions	Secondary actions can occur during crawling actions but they tend to be very subtle in nature and more often than not can be ignored.
Cycles and loops	Crawling actions make extensive use of cycles and loops to complete the illusion of movement.
Tempo	Used extensively to adjust the speed at which the crawling action occurs. Crawling occurs very slowly in comparison to most other forms of character movement. Adjust the tempo of the animation accordingly.

NOTE: Undoubtedly, you can probably identify a number of other animation primitives that are found in arcade games and are not described here. However, most are probably variations of the ones identified in this chapter. Master these primitives and the rest will come easily to you.

Creating Your Animation Sequences

As you can see, creating animations, even simple ones, involves a lot of time, planning, and attention to detail. However, the process can be simplified somewhat if you follow these nine steps:

1. **Conceptualize**—Before you start designing, always have a clear idea of what you want to animate and how it will look. This will save you time and effort since you can only really start the animation process once you have a clear idea of what needs to be done.
2. **Decide on object behavior**—After determining the object's look, you need to determine whether or not the object will be animated continuously (using cycles) or is a "one-off" and only animated once (no looping). Objects can have elements of both, however, so you need to decide on this before you start creating animation. Changing this behavior can complicate matters later on in the project.
3. **Choose a grid size**—The next step in the process is to choose a predefined grid size to contain and constrain the object that you are designing. Be sure to copy a number of grid squares to give yourself plenty of room to test and experiment with the animation sequences you create.
4. **Design the key-frames**—When you're finally ready to start designing, begin by drawing the motion extremes or key-frames needed for the object sequence. To save time and effort, just use simple shapes to represent the main actions of the object. For example, use stick figures if creating character animation or basic geometric shapes (i.e., circles, squares, triangles, etc.) if it's something else.
5. **Estimate the in-betweens**—Make an estimate of the number of in-betweens you think you will need to complete the sequence. Before you do this, remember that slower moving animations require more frames than faster moving animations. Be conservative when doing this. It's actually easier to add additional transition frames to a sequence than it is to remove them.
6. **Create object motion lines**—When done, trace the motion line and motion angles for the sequence. Use your painting program's Line tool to do this. It can always be erased later on. Before continuing, make sure that the properties of the motion line and motion angles are consistent with the type of object being animated. If not, make the appropriate adjustments to the sequence and

position the individual frames until the object starts to conform to these norms.

7. **Apply secondary actions and animation enhancements**—Add any secondary actions that might be needed, and if applicable check to see if the object exhibits sufficient flexibility. This is also a good time to add any additional "character" to your object(s). In other words, feel free to embellish the movement so it looks both convincing and enticing at the same time.
8. **Test each movement**—Don't forget to test every animation you create. The easiest way to do this is to use your painting program's Copy tool and copy one grid square to another and then apply an undoable undo. This temporarily combines two frames and then flips between them to produce a quick animated effect. For longer, more complex animations, see if your painting program offers an animation tool so that you can see the entire animation in context and at different tempos. A few of the ones mentioned in Chapter 6 actually do. In any case, be on the lookout for flaws in how the object moves and how the object appears. Often, you will catch minor mistakes such as discolored pixels or missing pixels, or even major mistakes such as improper movement (i.e., not enough exaggeration, too fast, etc.) at this stage of the process. Make corrections to the sequence as needed and do them before handing off your work to the programmer. It's recommended that you do at least two such tests for complex animations, while one test can suffice for less sophisticated objects.
9. **Repeat**—Repeat the previous eight steps to create all of the animations required by your game.

It's important to point out that different people have different opinions on how to go about this process. Some, like myself, prefer to create highly detailed figures and then animate them, while others prefer to work from rough items first.

How you choose to proceed really boils down to a matter of time, efficiency, and personal taste. When in doubt, particularly when you're first starting out, I recommend that you work from rough shapes. Later, when you're more experienced and comfortable with creating animation, you can work from more detailed object images.

General Animation Tips

- **Remember the relationship between frames and animation smoothness**—This relationship is one of the most important aspects of animation. In order to achieve the illusion of smooth motion, you need to use many frames. If design time or file size limits ever become an issue, you can always compensate by using fewer animation frames. Doing this produces a higher FPS, which can have the effect of making objects appear to move smoother than they actually are.

- **Always account for color**—Color can affect animations the same way it does other types of graphics. Always make sure that you choose suitable colors when creating your animations. Primary actions and secondary actions should be rendered in colors that make them easy to see. Otherwise, the effectiveness of the animation can be compromised. For more information on proper arcade game color usage and selection, refer to Chapters 7 and 8.
- **Use tempo wisely**—Tempo, if used properly, is your friend. If used incorrectly, it is your enemy. Use tempo to pace your animations. Your animations should never appear to move too fast or too slowly, as this will be perceived as unrealistic and distracting. Try to mimic nature. Study the speed at which different types of objects move in different situations. After a while, applying the correct tempo to your animated sequences will become second nature.
- **Try to individualize your objects**—Adding unique and individualized touches to your objects has the effect of making them seem real to the observer. Therefore, every distinct object you create and animate should have some sort of unique "personality" that distinguishes it from the other objects on the screen. One of the easiest ways to do this is to apply different degrees of exaggeration and embellishment (i.e., secondary actions) to each object.
- **Keep it simple**—Adding unnecessary complexity can ruin an animation sequence as it opens up the possibility of introducing flaws and other types of errors into it. To avoid doing this, keep your animations simple as much as possible. Therefore, stick with using established animation primitives and minimal frames unless the object requires more subtle effects. In other words, don't do any more work than you have to!
- **Use exaggerated elements**—As an animation device, exaggeration adds realism and depth to animations. Therefore, use it as much as possible. Exaggeration is especially important when working with short animation sequences as they have fewer frames available to them in order to create effective and convincing motion.
- **Constantly observe**—Successful animation requires the careful study of the objects around you. Study how different things move. Study books on animation such as those by Eadweard Muybridge in addition to studying how the animation featured in your favorite arcade games was created. Studying these sources will give you useful insights into animation techniques and will enable you to create better and more accurate animations.

In any case, don't get discouraged if the animation process doesn't go smoothly for you the first few times you try. Like most things, creating effective animations takes time and experience. Start off by working on simple animation sequences first. After you're comfortable with the basic animation process and are satisfied with the results, move on to animating more sophisticated subjects.

Remember, when it comes to creating arcade game animation, take baby steps. Never bite off more than you can handle. Take it slow. As the adage says, "Rome wasn't built in a day," and neither will your animations. Be patient and keep practicing. The more you do, the better you will eventually get at creating arcade game animation.

Animation Usage in Arcade Games

Although virtually every animation primitive described in this chapter has an application in every arcade game genre, some primitives are more commonly found in some genres than in others. For example, some games, such as shooters, have more complex graphic requirements and therefore can support a wider array of animation primitives. However, other genres such as Pong games tend to be less sophisticated and therefore cannot support the majority of animation primitives.

Table 9-34 summarizes the usage of the common animation primitives in the major arcade game genres.

TABLE 9-34: Summary of Animation Primitive Usage in Arcade Game Genres

Animation Primitive	*Maze/Chase*	*Pong*	*Puzzler*	*Shooter*	*Platformer*
Cylindrical	✓	✓	✓	✓	
Rotational	✓	✓	✓	✓	
Disintegration	✓	✓	✓	✓	✓
Color flash	✓	✓	✓	✓	✓
Scissors	✓	✓		✓	
Growing	✓	✓	✓	✓	✓
Shrinking	✓	✓	✓	✓	✓
Piston	✓		✓	✓	
Squeeze	✓		✓	✓	
Swing	✓		✓	✓	✓
Slide					✓
Open/close	✓	✓	✓	✓	✓
Bounce			✓	✓	
Stomp	✓		✓	✓	
Slinking				✓	✓
Flying				✓	✓
Walking				✓	✓

Animation Primitive	*Maze/Chase*	*Pong*	*Puzzler*	*Shooter*	*Platformer*
Running				✓	✓
Jumping			✓	✓	✓
Crawling					✓

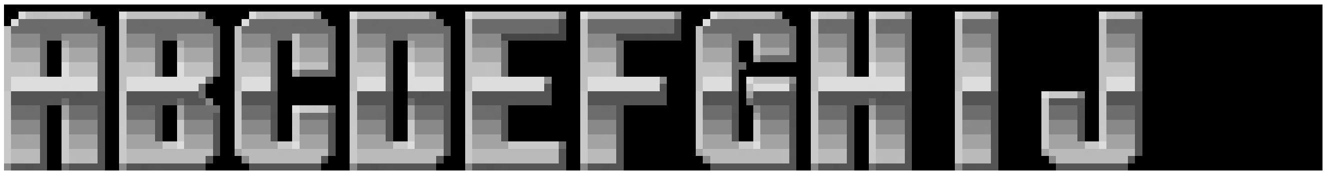
Due to limitations imposed by different design styles, not all animation primitives can or should be used. For example, the more complex animation primitives really are not suitable for use in a retro-style arcade game. It simply doesn't look right. Conversely, games with realistic design styles should not overuse simple animation primitives as they undermine the element of realism present in these games.

Table 9-35 summarizes the suitability of animation primitives in the most common design styles.

TABLE 9-35: Summary of Animation Primitive Usage in Arcade Game Design Styles

Animation Primitive	*Cartoon*	*Retro*	*Realistic*
Cylindrical			✓
Rotational	✓	✓	✓
Disintegration	✓	✓	✓
Color flash	✓	✓	✓
Scissors	✓	✓	
Growing	✓	✓	✓
Shrinking	✓	✓	✓
Piston	✓	✓	
Squeeze	✓	✓	
Swing	✓	✓	
Slide	✓	✓	✓
Open/close	✓	✓	✓
Bounce		✓	
Stomp	✓	✓	
Slinking	✓		✓
Flying	✓	✓	✓
Walking	✓	✓	✓
Running			✓
Jumping	✓	✓	✓
Crawling			✓

NOTE: The information presented in Tables 9-34 and 9-35 are general suggestions only. Every arcade game project is unique and can define its own rules for the use of animation primitives.



Chapter 10

Fonts and Arcade Games

In this chapter, you'll learn about:

- **Fonts**
- **Font characteristics**
- **Font legibility**
- **Common font formats**
- **Platform-specific font support**
- **General rules for using fonts in arcade games**
- **Using fonts in arcade games**

No discussion of arcade game graphics design would be complete without covering at least some aspects of fonts. The purpose of this chapter is to serve as a primer on fonts and their correct use in arcade games.

What are Fonts?

Fonts (also called typefaces) are sets of letters, numbers, and other special symbols that share a particular style and appearance. Fonts play an important role in arcade game graphics design. They can help give a game character or reinforce it and also serve various utility roles. Without them, arcade games would not be able to display essential information such as game help, score and life indicators, game titles, or even game credits!

All fonts are composed of basic elements called *characters*. Characters are the letters and numbers we see and use every day for our written communication. Almost every font in use today also has a unique name associated with it (i.e., New York, Times, etc.) as well as a description of its appearance (i.e., Futura, Bold, Condensed, etc.). We use these items to help us manage and specify fonts in the game artwork we design.

Font Characteristics

Several characteristics describe how fonts appear on the screen. These include:

- Serifs
- Sans serifs
- Monospaced
- Proportional
- Bitmapped
- Scaleable

Serifs

Serifs are the small stems that accent the main *strokes*, or lines, that make up each character in a particular font. For example, in Figure 10-1, the letter T is set in a font called Times New Roman and has two horizontal serifs (at the bottom) and two vertical serifs (at the top).

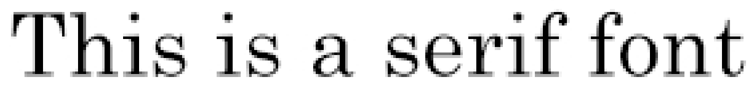


FIGURE 10-1: Serif Font Example

Serif fonts are useful for any game text that requires a formal or serious treatment such as in a title or logo. This ability to convey authority is one of the reasons why serif fonts are so popular with newspapers and magazines.

Sans Serifs

Sans serif fonts are the exact opposites of serif fonts. That is, they are fonts whose characters do not contain any serifs.

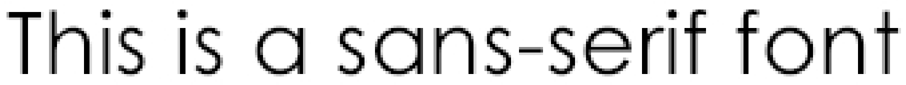


FIGURE 10-2: Sans Serif Font Example

Compared to serif fonts, sans serif fonts are better suited for games that don't require a serious creative treatment. In addition, sans serif fonts also tend to be easier to read than serif fonts, particularly on computer screens where their simple construction allows them to be easily seen at relatively low screen resolutions. This makes them very useful in arcade games for displaying all sorts of game-related information.

Monospaced

Fonts that are *monospaced* have an equal amount of horizontal space between each character.

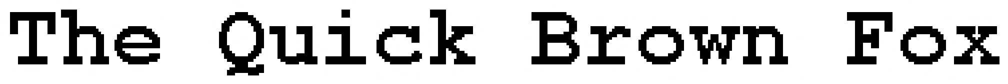


FIGURE 10-3: Monospaced Font Example

Monospaced fonts are commonly used for displaying information that must line up on-screen in a particular way. Examples of where this might occur include source code or a game's high score table. However, they are not very good for displaying large amounts of closely connected text such as is commonly found in game help screens and on-screen instructions. This is because each character in a monospaced font is surrounded by a fixed amount of white space which has the effect of making individual characters difficult to discern when many words are displayed on the screen at once.

NOTE: Most DOS fonts are of the monospaced variety.

Proportional

In fonts that are *proportional*, each character is given only as much horizontal space as it needs. For example, in a proportional font the letter "I" won't take up as much space as the letter "W" does.

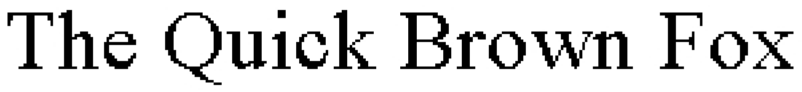


FIGURE 10-4: Proportional Font Example

Incidentally, proportional fonts are very popular for text-heavy applications because their characters are easy to distinguish from each other.

NOTE: Most Windows, Linux (using X Windows), Java, and Macintosh fonts are of the proportional variety.

Bitmapped

Bitmapped fonts are fonts whose characters are composed of individual dots and have a fixed size. Because of this, they are only useful at a particular resolution and can't be resized without seriously affecting their overall quality.

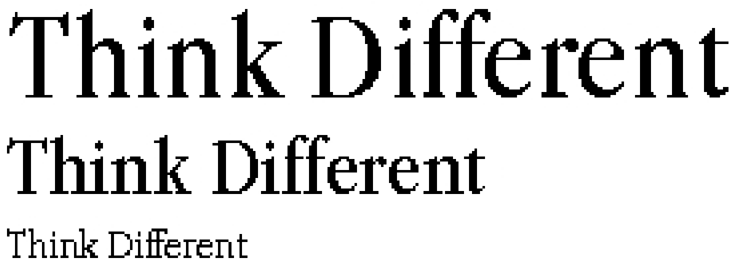


FIGURE 10-5: Bitmapped Font Example

Bitmapped fonts were once quite common on computers but have since fallen into disuse due to their inability to change size easily without diminishing their quality. In addition, they are less flexible than other types of fonts since an entirely new bitmapped font set is required for every change in size.

NOTE: Many character-oriented operating systems, such as DOS and Linux, use bitmapped fonts for displaying text information. In addition, both Windows and the Macintosh also use bitmapped fonts for a variety of system-related purposes.

Scaleable

A *scaleable font*, unlike a bitmapped font, is defined mathematically and can be rendered at virtually any size without diminishing its quality or requiring a separate font set.

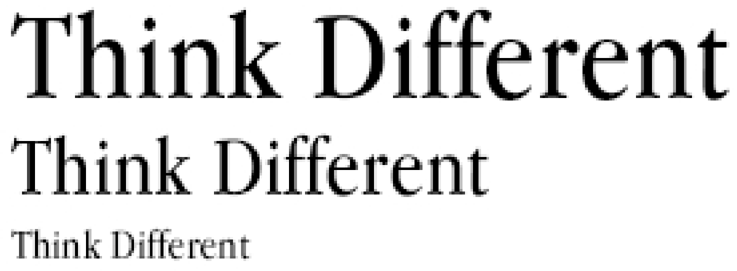


FIGURE 10-6: Scaleable Font Example

Compared to bitmapped fonts, scaleable fonts can easily be resized and manipulated without the need for additional character sets and without loss of quality.

NOTE: All modern operating systems such as Windows, Linux, and the Macintosh use scaleable fonts (i.e., TrueType) to display text on-screen.

Font Legibility

To be effective in conveying its message in a game, a font must be *legible*, or easy to read and distinguish on-screen. Several properties can influence a font's legibility. These are:

- Face
- Style
- Size
- Aliased
- Anti-aliased
- Color
- Weight
- Leading
- Kerning
- Tracking

Face

A font face is a means of specifying a particular font design. Essentially, all fonts offer one of two faces: *decorative* and *non-decorative*.

Decorative fonts are fonts that exhibit some sort of artistic design or theme. For example, a decorative font face called Handwriting renders text as if it were drawn in someone's personal handwriting.

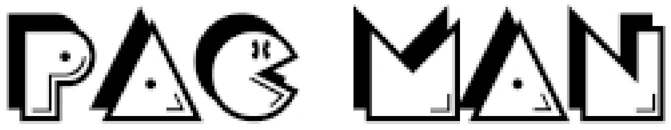


FIGURE 10-7: Decorative Font Example

Non-decorative fonts are the normal, unadorned fonts we see and use every day. Most serif and sans serif fonts fall into this category.

Decorative fonts are very useful for livening up the display of textual information. However, they are also notorious for being difficult to read. The extent of this problem depends on the degree of the decoration, the screen resolution, and size of the font. Therefore, be very careful when using them in your games.

Style

Fonts can use a variety of different styles to convey certain meanings and emotions in text. For example, you can use bold fonts to emphasize the importance of certain words. Similarly, fonts that are italicized are often used to emphasize words or to mark certain textual items such as a quote or a phrase.

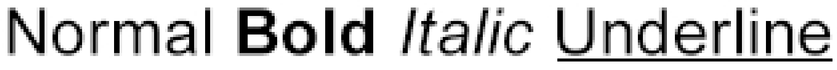


FIGURE 10-8: Example Font Styles

With few exceptions, the font styles shown in Figure 10-8 can be applied at the same time, although this isn't recommended, especially if you want to keep your text legible.

Size

Fonts are usually measured in units called *points*. A point is roughly equivalent to 1/72 of an inch. Font size is determined by measuring from the bottom of the font's lowest character (descender) to the top of its tallest character (ascender), as shown in Figure 10-9.

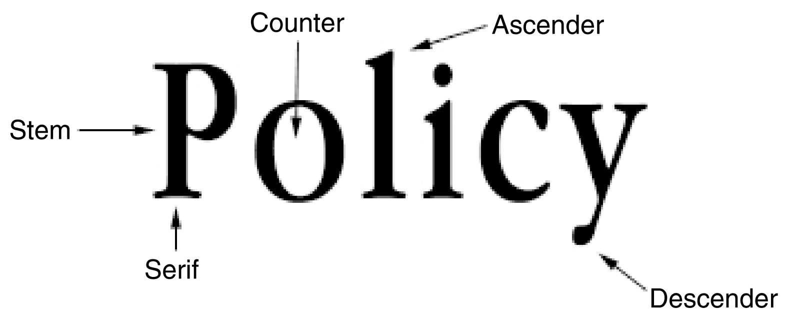


FIGURE 10-9: Font Element Diagram

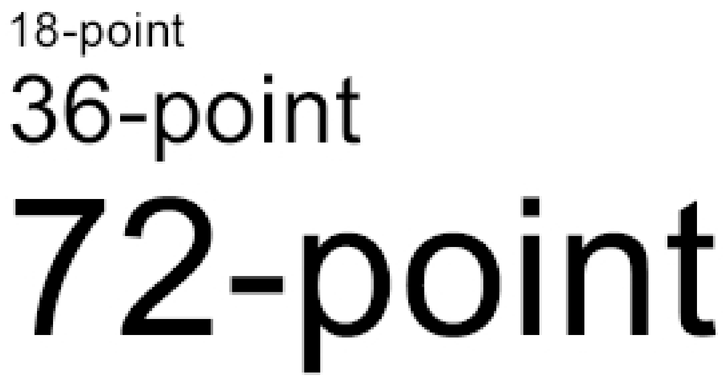


FIGURE 10-10: Examples of Different Font Sizes

This scheme causes some fonts to sometimes appear larger than others do even if they are the same point size. For example, compare 12-point Times with 12-point Helvetica. Notice how much larger the text rendered in Helvetica seems.

As you might expect, a font's legibility is directly proportional to its size. As a general rule, larger fonts are more legible and therefore easier to read than smaller fonts regardless of the current screen resolution.

Table 10-1 compares the legibility of different fonts when used in arcade games.

TABLE 10-1: Font Legibility and Size in Arcade Games

Font Size	*Comments*
Less than 8 point	Virtually unreadable except at very high screen resolutions and then only useful for icons or captions.
8-12 point	Passable for most types of game text.
12-18 point	Easy to read on-screen. Excellent for game text.

Font Size	*Comments*
18-24 point	Easy to read on-screen. Excellent for game titles and game text.
24-36 point	Very easy to read on-screen. Excellent for displaying game titles and logos.
36-48 point	Very easy to read on-screen. Excellent for game titles.
Greater than 48 point	Very easy to read on-screen but of limited use due to the large size.

NOTE: A font's face, style, and the current screen resolution can all influence legibility. For example, a font displayed at a resolution of 640x480 will be more legible at the same point size than a font displayed at a resolution of 320x240.

Aliased

If you recall our discussion in Chapter 2, aliasing is the undesirable distortion of a graphic image due to insufficient screen resolution. As a result, fonts that are *aliased* appear blocky and coarse when displayed on-screen.

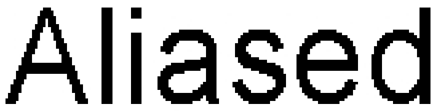


FIGURE 10-11: Aliased Font Example

Aliased fonts are quite common on older systems, particularly those that don't use a graphical, windowing operating system, i.e., DOS, or for system display functions such as menus and dialog boxes.

Anti-Aliased

Fonts that are *anti-aliased* use shaded pixels around their edges to reduce or eliminate the effects of aliasing as they are displayed on-screen. This makes such fonts look much more attractive when compared to aliased fonts. Notice how much smoother the text in Figure 10-12 seems when compared to the text in Figure 10-11.

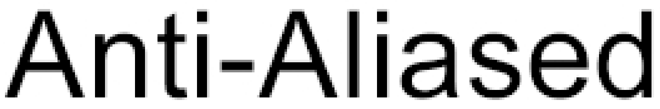


FIGURE 10-12: Anti-Aliased Font Example

Most modern computers support anti-aliased fonts on their displays. For example, Macintosh systems support anti-aliased fonts from both the *Adobe Type Manager* program and the Appearance Control Panel while Windows systems support anti-aliased fonts via the Font Smoothing option in its Display Properties Control Panel.

However, it's important to understand that due to resolution constraints, anti-aliasing won't always improve the quality and readability of a font. In fact, sometimes it can even make the font less legible. In general, anti-aliasing produces better results as the font gets larger.

Table 10-2 provides some guidelines of when to use anti-aliasing on your fonts in a game.

TABLE 10-2: Font Anti-Aliasing Usage Guidelines

Font Size	*Comments*
Less than 8 point	Virtually unreadable when anti-aliased. Do not anti-alias at these sizes.
8-12 point	Difficult to read but passable for most types of game text when anti-aliased.
12-18 point	Easy to read on-screen. Produces good results when anti-aliased.
Greater than 24 point	Very easy to read on-screen. Produces excellent results when anti-aliased.

Color

Color looks at the overall aesthetic quality of a particular font. A font with *perfect color* is a font that has good spacing between characters, a good design, and proper character balance (i.e., one letter looking too dark or light when compared to one another).

Gaudy fonts (i.e., those that are excessively decorative) are considered to have poor font color. Poor font color can affect how good a font looks as well as its legibility on-screen.

Figure 10-13 compares font color between two different fonts. In this example, the font at top has relatively poor font color while the font at the bottom has a good font color. Can you see the difference yourself?

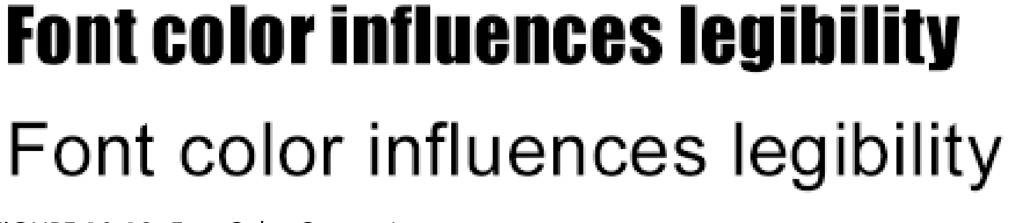

Font color influences legibility
Font color influences legibility

FIGURE 10-13: Font Color Comparison

Weight

A font's *weight* is a measurement of the vertical thickness of the individual characters in a font. Font weight is specified and determined according to several grades. These include extra-light, light, book, medium, bold, extra bold, and black. Fonts get darker and heavier in appearance as their weight increases. It is important to point out that not all fonts support all of these different weights.

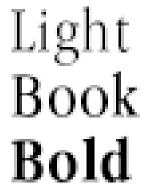


FIGURE 10-14: Font Weight Example

Leading

Leading is a measurement of the vertical space between lines of characters. Leading can be used to adjust the color of lines of text. Lines with too little leading can appear cramped and crowded, while lines with too much leading can appear too loose and open.

Unfortunately, many game designers fail to take leading into account when they place text on the screen. Poor leading can make text difficult to find and read when displaying important game-related information.

Figure 10-15 shows an example of how leading can affect the color of a line of text. In this example, Lines 1 and 2 have too little leading while Lines 3 and 4 are just right.

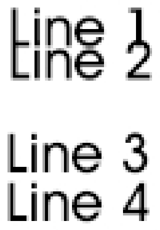


FIGURE 10-15: Leading Example

NOTE: Many bitmapped system fonts also have poor font leading characteristics.

Kerning

Kerning is a method of reducing the space allotted to one or both sides of a character to make it fit more comfortably between its neighbors. Kerning is frequently used to adjust and improve the color of a particular font.

Figure 10-16 shows an example of how kerning alters character spacing and the appearance of text.

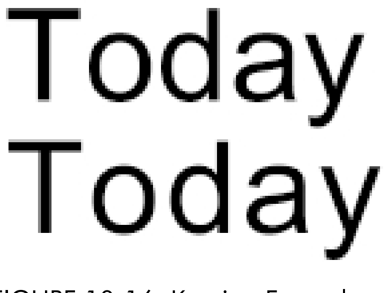


FIGURE 10-16: Kerning Example

Tracking

Tracking is a measurement of the overall letter spacing in a line of text. Adjusting the tracking of a line can also improve its color and its legibility.

Common Font Formats

Fonts are available in a number of different formats. These formats dictate both their features and the platforms with which they are compatible. The most common font formats used in arcade game graphics are organized in these categories:

Bitmapped:

- ROM fonts
- ZSoft fonts
- GEM fonts
- Fastgraph fonts
- Custom game fonts

Scaleable:

- Borland Stroked fonts
- TrueType fonts
- System fonts

ROM Fonts

Native Platform(s): DOS, Linux, and the Macintosh

File Extension(s): N/A

ROM fonts are bitmapped fonts that are built into your computer's ROM (Read-Only Memory). Because they come built-in, ROM fonts do not require the installation of additional font sets in order to be used.

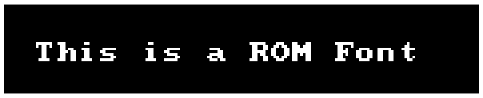


FIGURE 10-17: ROM Font Example

However, despite these advantages, ROM fonts have a number of disadvantages, including:

- **They're monospaced**—All ROM fonts are monospaced and were designed to only fit within a predefined pixel grid. This gives them poor overall color and affects their on-screen legibility.
- **They're bitmapped**—ROM fonts are bitmapped, and as such cannot be easily resized.

- **They have poor leading**—ROM fonts weren't designed to support flexible character leading. This makes them less than ideal for displaying large amounts of text.
- **They have fixed kerning—**ROM fonts have fixed character spacing. This causes them to produce cramped lines of text when displaying large amounts of textual information.
- **They support limited faces**—Most ROM fonts support only one font face. This makes them inflexible for many purposes, especially when you want to produce a particular look in a game.
- **They support limited styles**—Most ROM fonts offer only one display style and do not support bolding, italics, or underlining. This makes them useless for emphasizing certain textual elements.

ROM fonts are traditionally used by character-based operating systems such as DOS and Linux, but they can also be seen on the Macintosh and Windows platforms as well.

At one time, using ROM fonts in arcade games was the rule and not the exception, and these fonts were frequently used to display text on help screens, label menu options, and print various game status information. However, given improvements in computer capabilities and display technologies over the years, this situation no longer applies. Simply put, using ROM fonts in your arcade games makes them looks crude and amateurish. Therefore, avoid them, as there are many other alternatives available.

TABLE 10-3: ROM Font Characteristics

Platform	*Supported Sizes (points or pixels)*	*Proportional*	*Adjustable Leading*	*Adjustable Kerning*	*Adjustable Faces*	*Adjustable Styles*
DOS	8x8 or 8x16 pixels				✓*	
Windows	N/A	N/A	N/A	N/A	N/A	N/A
Linux	8x8 or 8x16 pixels					
Macintosh	9, 10, 12, 14, 18, 24 points				✓*	✓

* Denotes that these platforms can replace the default system font with another in certain situations.

NOTE: You can alter the appearance of ROM fonts in certain situations. For example, using a ROM font editing program, you can alter the appearance of DOS's ROM character set.

ZSoft Fonts

Native Platform(s): DOS

File Extension(s): .FNT, .fnt

ZSoft originally introduced this bitmapped font format with the introduction of its popular *PC Paintbrush* painting program during the mid- to late 1980s. Owing to the popularity of the *PC Paintbrush* program, these fonts soon became an unofficial DOS font standard and were widely used in PC-based graphics and desktop publishing applications through the early 1990s. Therefore, you can still find large numbers of fonts available in this format.

As with all bitmapped fonts, ZSoft fonts can't be resized without losing their display quality. In addition, ZSoft fonts are typically monochrome but can use multiple colors in certain situations.

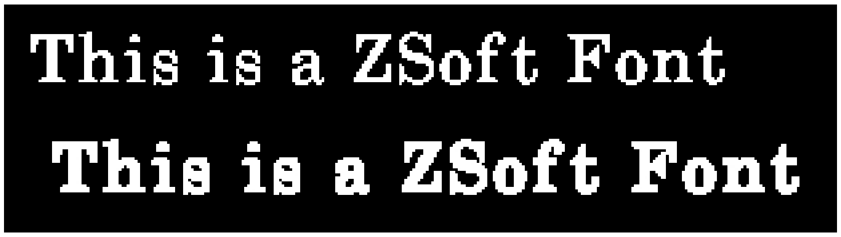


FIGURE 10-18: ZSoft Font Example

TABLE 10-4: ZSoft Font Characteristics

Versions	*Proportional*	*Adjustable Leading*	*Adjustable Kerning*	*Adjustable Faces*	*Adjustable Styles*	*Adjustable Sizes*
N/A	✓+				✓	

+ Denotes that they can be monospaced as well depending on how the font was designed.

NOTE: *Improces*, a painting program mentioned in Chapter 6, is compatible with ZSoft fonts.

GEM Fonts

Native Platform(s): DOS

File Extension(s): .FNT, .fnt, .GFT, .gft

The GEM font format was first introduced in the mid-1980s with the advent of Digital Research, Inc.'s GEM (Graphics Environment Manager) operating system shell. Although GEM never took off as a desktop interface on the PC platform, it did enjoy significant commercial success in desktop publishing circles when it became the interface for the popular *Ventura* desktop publishing system. Because of this legacy, you can still find large numbers of GEM-compatible fonts from various public domain, shareware, and commercial sources.

GEM fonts are normally bitmapped. As such, they suffer from the same issues that plague all bitmapped fonts. However, some later implementations of the GEM font format were actually scaleable but never caught on in any significant way. GEM fonts are also monochrome and can't support more than two colors per character.

NOTE: GEM fonts were also quite common on the Atari ST platform. However, you can't use these fonts without first converting them since Atari GEM fonts are encoded somewhat differently than those used on PC-compatible systems.

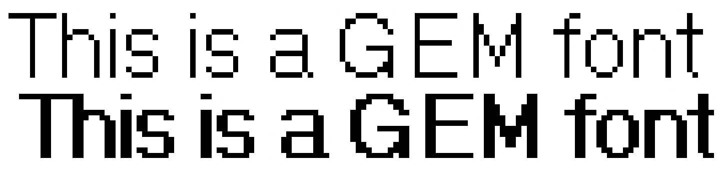


FIGURE 10-19: GEM Font Example

TABLE 10-5: GEM Font Characteristics

Versions	*Proportional*	*Adjustable Leading*	*Adjustable Kerning*	*Adjustable Faces*	*Adjustable Styles*	*Adjustable Sizes*
Intel	✓+	✓*	✓*		✓	
Motorola (Atari)	✓+	✓*	✓*		✓	

* Denotes that kerning and leading can be adjusted depending on the capabilities of the software used.
+ Denotes that they can be monospaced, as well, depending on how the font was designed.

NOTE: *NeoPaint for DOS*, a painting program mentioned in Chapter 6 and included on the book's accompanying CD-ROM, is compatible with GEM fonts.

Fastgraph Fonts

Native Platform(s): DOS

File Extension(s): .FGF, .fgf

The Fastgraph font format is a proprietary, bitmapped font format developed by Ted Gruber Software for use with its *Fastgraph for DOS* graphics programming library.

Although a bitmapped font, the Fastgraph font format can support a variety of programmed color and spacing effects.

TABLE 10-6: Fastgraph Font Characteristics

Versions	*Proportional*	*Adjustable Leading*	*Adjustable Kerning*	*Adjustable Faces*	*Adjustable Styles*	*Adjustable Sizes*
N/A	✓+	✓*	✓*			

* Denotes that kerning and leading can be adjusted depending on the capabilities of the software used.
+ Denotes that they can be monospaced, as well, depending on how the font was designed.

Custom Game Fonts

Native Platform(s): DOS, Windows 3.1, 95, 98, NT 4.0, and 2000, Linux, Macintosh, and Java

File Extension(s): N/A

We've all seen arcade games at one time or another that featured decorative fonts that appeared as if they were three-dimensional or metallic, etc. Well, these fonts aren't really fonts at all. Rather, they are hand-drawn bitmapped images that are used as fonts. Through special programming, these bitmaps can be used to display text and other information in an arcade game screen.

Since they are bitmaps, custom game fonts can assume virtually any size, shape, color, or style you can dream up. This makes them particularly effective in enhancing the visual look and feel of an arcade game.

On the other hand, because they're bitmaps, custom game fonts can't be easily resized nor do they offer traditional font amenities like adjustable leading or kerning. Furthermore, they require more time and effort to implement than other font formats because they usually have to be designed completely from scratch. Finally, they require more preparation and work from the programmer's standpoint since the programmer must devise routines and mechanisms to properly handle their display and integration with the game.

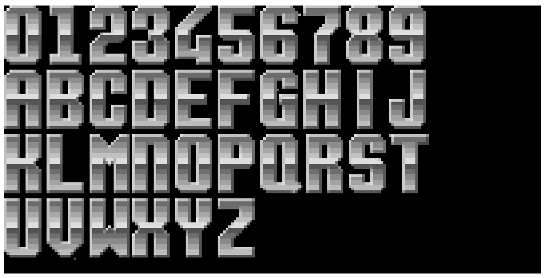


FIGURE 10-20: Custom Game Font Example

TABLE 10-7: Custom Bitmap Font Characteristics

Versions	*Proportional*	*Adjustable Leading*	*Adjustable Kerning*	*Adjustable Faces*	*Adjustable Styles*	*Adjustable Sizes*
N/A						

NOTE: Custom bitmapped font sizes tend to be specified in pixels rather than points.

NOTE: You can create custom game fonts with any painting program or image editor mentioned in Chapter 6.

Borland Stroked Fonts

Native Platform(s): DOS

File Extension(s): .CHR, .chr

This scaleable font format made its debut with Borland's Turbo Pascal programming language during the late 1980s. A monochrome-only font format, Borland Stroked fonts remained in use through the mid-1990s until the advent of the Windows platform, which abandoned this technology in favor of other scaleable font technologies like TrueType.

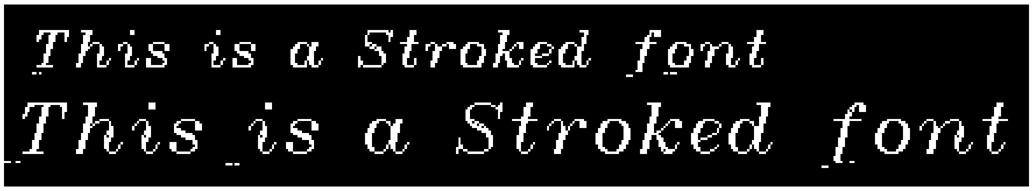


FIGURE 10-21: Borland Stroked Font Example

TABLE 10-8: Borland Stroked Font Characteristics

Versions	*Proportional*	*Adjustable Leading*	*Adjustable Kerning*	*Adjustable Faces*	*Adjustable Styles*	*Adjustable Sizes*
N/A	✓*	✓*	✓*	✓	✓	✓

* Denotes that kerning and leading can be adjusted depending on the capabilities of the software used.

NOTE: *Improces*, a painting program mentioned in Chapter 6, is compatible with Borland Stroked fonts.

TrueType Fonts

Native Platform(s): Windows 3.1, 95, 98, NT 4.0, and 2000, Linux, Macintosh, and Java

File Extension(s): .TTF, .ttf

Apple originally developed the TrueType font format in 1990 as a means of challenging Adobe (once the leading font developer and technology supplier) in the hot desktop publishing market. The technology made its debut on the Macintosh platform and the technology was later supplied to Microsoft, which in 1991 introduced TrueType on the PC with the release of Windows 3.1.

TrueType fonts are inherently scaleable. Therefore, they enjoy all of the advantages that this provides, including the ability to scale text to any size without the loss of quality. As designed, TrueType fonts are monochromatic. This allows them to be used for printing as well as for screen display.

TrueType fonts are the standard font formats for both Windows and Macintosh systems and virtually all graphics programs on these platforms support them. Until recently, TrueType fonts weren't compatible with Linux but recent implementations of that operating system have made their use possible on that platform as well.

Despite their popularity, you can't transfer TrueType fonts from one platform to another without first converting them. This is due to platform-specific font-encoding differences. Fortunately, this is relatively easy to do with the proper software.

TABLE 10-9: TrueType Font Characteristics

Versions	*Proportional*	*Adjustable Leading*	*Adjustable Kerning*	*Adjustable Faces*	*Adjustable Styles*	*Adjustable Sizes*
Windows	✓+	✓*	✓*	✓	✓	✓
Macintosh	✓+	✓*	✓*	✓	✓	✓

* Denotes that kerning and leading can be adjusted depending on the capabilities of the software used.
+ Denotes that they can be monospaced, as well, depending on how the font was designed.

System Fonts

Native Platform(s): DOS, Windows 3.1, 95, 98, NT 4.0, and 2000, Linux, Macintosh, and Java

File Extension(s): N/A

System fonts are those fonts that come bundled with a particular operating system or computer platform. They don't come built-in like ROM fonts are but are the default fonts supported by a particular system.

With the exception of DOS and character-based Linux implementations, system fonts are almost exclusively TrueType, although some are of the bitmapped variety as well.

Table 10-10 shows the different default fonts that come with each platform "out-of-the-box."

TABLE 10-10: Default System Fonts on Different Platforms

Platform	*Default System Font Faces*
DOS	8x8 and 8x16 ROM BIOS font
Windows	Arial, Courier New, FixedSys, Modern, MS-Serif, MS-Sans Serif, Tahoma, Terminal, Times New Roman
Macintosh	Times, Charcoal*, Chicago, Courier, Gadget*, Geneva, Helvetica, Monaco, Palatino, New York, Textile*
Linux	Fonts vary depending on Linux distribution but they typically contain font faces similar to the Courier, Times New Roman, Geneva, and Helvetica varieties.
Java	Courier, Helvetica, Times New Roman, ZapfDingbats, Dialog (a slightly modified form of Helvetica)

* Denotes fonts included with newer MacOS versions.

The primary advantage offered by system fonts is that they are always available on a given platform. This allows you to specify them in your arcade games without the fear of them not being available on a user's system. Therefore, it's safe to use them whenever you need to display non-graphic text in your game.

Platform-Specific Font Support

As I mentioned earlier, although some font formats are available with multiple platforms, not all of these fonts can be used without some sort of conversion process.

TABLE 10-11: Summary of Font Support

Font Format	*DOS*	*Windows*	*Linux*	*Macintosh*	*Notes*
ROM BIOS	✓	✓	✓	✓	
ZSoft	✓				
GEM	✓	✓			Be wary of GEM fonts coming from the Atari ST platform, as they will need to be converted to the Intel format before they can be used.
FastGraph	✓				
Custom bitmapped	✓	✓	✓	✓	

Font Format	*DOS*	*Windows*	*Linux*	*Macintosh*	*Notes*
Borland Stroked	✓				
TrueType		✓	✓	✓	You can import many TrueType fonts into DOS applications using utilities like *TT2GEM* and export them as GEM format fonts.

NOTE: To help make the process of converting fonts between formats and platforms easier, several font conversion utilities are available on the book's accompanying CD-ROM. Please refer to Appendix B for more details on these programs.

General Rules for Using Fonts in Arcade Games

Now that you have a grasp on the fundamentals of fonts and the various font formats, you need to understand the fundamental rules of using fonts in your games. Most designers will tell you that there's a right way to use fonts and a wrong way to use them. These guidelines are provided to help you to learn the right way.

- **Always emphasize font legibility over font aesthetics**—The primary purpose of fonts in a game (or any other application for that matter) is to display textual information in a consistent and legible manner—nothing more, nothing less. Therefore, your primary concern should be choosing fonts for their legibility rather than their aesthetic value. Of course, you are encouraged to look for fonts that are attractive as well as readable, but legibility should always be your most important consideration in selecting a font.
- **Avoid custom bitmap fonts unless absolutely necessary**—For all of their flexibility, simply put, creating and using custom bitmap fonts is a pain—a pain for you and a pain for the programmer. In the past, custom bitmap fonts offered designers flexibility and visual characteristics that many existing font technologies didn't. However, today, this is no longer true. Modern font formats such as TrueType now support so many different faces and styles that there is really no practical reason to rely on custom bitmap fonts except for very specialized purposes. Therefore, avoid using them as much as possible in your game artwork.
- **Avoid displaying words entirely in uppercase**—Text displayed exclusively as uppercase type (i.e., all capitals) is significantly harder to read than mixed type (i.e., the combination of lower- and uppercase characters). This is because uppercase text tends to lack the unique shapes that users need to help them distinguish between letters and words. Also, avoid capitalizing too many letters in your text. This can potentially cause unnecessary user

confusion. When in doubt, only capitalize the first letter in each line of text and the first letter of proper nouns such as the names of people, places, or things.

- **Avoid overly decorative fonts for body text**—Overly decorative fonts can be difficult to read on-screen for the same reasons that most serif fonts are. Also, be careful when using them for any text less than 16 points in size.
- **Avoid overusing bold fonts**—Bolding text is used to give a word or phrase emphasis. However, bold fonts tend to be difficult to read when used over large amounts of copy. This is due to the fact that bolded fonts have thicker strokes than normal text. This additional stroke thickness, particularly at lower screen resolutions, can dramatically affect the amount of space that's available inside letters like "o," "e," "d," and "g." Users depend on these spaces to recognize words. As this intra-letter spacing gets smaller, the text can become harder and harder to recognize.
- **Avoid overusing italic fonts**—Italics are meant to provide words and phrases with a "soft" emphasis. However, italic text, when used in large amounts, can disrupt how a user reads information presented on the screen. Under normal circumstances, italics confuse the reader and slows down the pace at which they can decipher text. This explains why italics are effective for emphasizing certain words or phrases. Yet, when used in large amounts, this characteristic of italics can also make text more difficult to read and the information you're trying to convey more difficult to remember.
- **Avoid overusing underlined fonts**—Underlining is commonly used interchangeably with italics in order to emphasize certain words or phrases in a subtle manner. Unfortunately, underlining doesn't always translate very well to the computer screen due to the limitation of available screen resolution. In addition, when used on blocks of text with tight leading, underlining can drastically affect legibility. Therefore, use underlining sparingly or, better yet, not at all.
- **Avoid using anti-aliased fonts for small text**—Anti-aliased fonts are very effective for displaying large text items, but due to resolution limitations they do not produce very readable text at very small text sizes. See Table 10-2 for more details.
- **Make use of kerning and tracking as much as possible**—Letter and line spacing can have a significant impact in the effectiveness of your message, especially when rendered on-screen where you have to contend with limited screen resolution. Kerning tends to become more important as font size increases. To minimize legibility issues, keep kerning narrower at large font sizes and wider at small font sizes. Similarly, tracking can make text look too cramped at small font sizes and too open at large font sizes. Adjust it to suit your circumstances.

- **Pay attention to line spacing**—Line spacing, or leading, can be a very effective aid in drawing the user's eye from word to word. Very narrow line spacing can cause the user to return to the same line of text. Meanwhile, line spacing that is too wide can slow the user down and force them to look for the start of the next line of text. Although line spacing will vary according to the font style and size you choose, a good rule of thumb is to add two to four points between the lowest descender and highest ascender of a given line of text. So, for example, if you're using a 12-point font, set the leading to 14.
- **Use centered text carefully**—Centered text can be very effective for focusing the user's attention on certain text elements such as titles and headlines. However, if used too much or used improperly, centered text can have a detrimental effect on text readability. In addition, when used too much in a game, centered text can appear amateurish to the player.
- **Use sans serif fonts for game text**—Sans serif fonts are inherently easier to read on-screen than text that uses serif fonts. This is because the individual character serifs can blend together due to screen resolution limitations. Serif fonts are fine to use for headlines and the like because such text usually tends to be large and well spaced.
- **Use sans serif fonts for casual text**—Due to the simple construction of their characters, sans serif fonts are ideally suited for presenting a casual, laid-back feeling on-screen. Use them for any text that doesn't require an authoritative air.
- **Use serif fonts for elegant or serious text**—Serif fonts are best used for text that requires a sense of elegance.

Using Fonts in Arcade Games

Fonts, when properly used, can liven up and enhance an arcade game's graphics in addition to their primary role of displaying important game-related information. In arcade games, fonts are usually relegated to these three areas:

- Game titles
- Body text
- Status indicators

Game Titles

Game titles consist of any words or phrases used to describe and label information displayed on a given game screen.

For our purposes, any text greater than 16 points in size can be considered a game title. Game titles are usually between one and six words in length.

Because they serve to announce important information on a screen, game titles should be rendered in a font that is both legible and projects a noticeable presence. This means that the font used should dominate whatever else is displayed on-screen. Simply put, a game title is ineffective if the other text elements displayed "crowd out" the title's font.

Game titles can be rendered in either serif or san serif fonts. Just remember the rules described in the previous section.

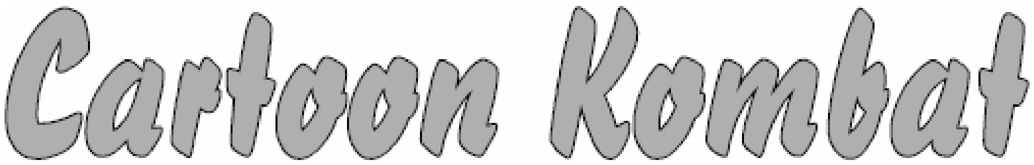


FIGURE 10-22: Game Title Example

Body Text

Body text, or game text, consists of any words or phrases used to convey information on a given game screen.

Body text can range from one sentence to one page in length. For our purposes, any text less than 16 points in size can be considered body text.

As the purpose of body text is to present information to the user, body text should stress legibility over everything else, including style.

FIGURE 10-23: Body Text Example

Status Indicators

Status indicators are the words and phrases used to indicate game status on a given game screen. Examples of status indicators include score displays, life displays, level displays, health displays, and so on. Status indicators are usually no longer than two or three words. However, unlike either titles or body text, status indicators are not limited in size. They can be displayed in any font size or style as long as the information is legible.

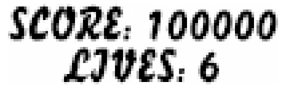


FIGURE 10-24: Status Indicator Example

Table 10-12 provides some style guidelines for fonts in arcade games.

TABLE 10-12: Arcade Game Font Style Guide

Arcade Game Text	*Bold*	*Italic*	*Size*	*Proportional*	*Monospaced*	*Face*	*Anti-aliased*
Game titles	✓	✓	Greater than 16 points	✓	✓	Decorative	✓
Body text			Less than 16 points		✓	Non-decorative*	
Status indicators	✓	✓	Any size	✓	✓	Non-decorative*	

* Depends on the legibility of the font being used.

- **Game titles**—Title text may be bolded or italicized because their size tends to minimize the issue of screen resolution. Title text works best when it is displayed using proportional and anti-aliased fonts.
- **Body text**—Body text shouldn't be bolded or italicized due to screen resolution limitations. Although body text can be proportional, monospaced fonts offer the best legibility for most types of body text, especially when lots of text is involved. It's also not a good idea to anti-alias body text as legibility may be affected. When in doubt, refer to Table 10-1 and experiment with the values shown there.
- **Status indicators**—Status indicators have very few stylistic restrictions on them. Pretty much anything can go as long as legibility isn't compromised by the font face and style used.

Arcade Game Font Recommendations

Every font format has its place in arcade game graphics design. Use the information presented in Tables 10-13 and 10-14 to help determine which font formats and font styles to use in your own game projects.

TABLE 10-13: Font Format Game Font Recommendations

Font Format	*Game Titles*	*Body Text*	*Status Indicators*
ROM BIOS		✓	✓
ZSoft	✓	✓	✓
GEM	✓	✓	✓
Fastgraph	✓	✓	✓
Custom Bitmapped	✓	✓	✓
Borland Stroked	✓		
TrueType	✓	✓	✓

- **ROM fonts**—These fonts are excellent for body text but are virtually useless for title text. Although they can be used for status indicators, this isn't recommended due to their overall inflexibility with regard to sizing and style.
- **ZSoft fonts**—As a bitmapped font, ZSoft fonts work well for all arcade game text applications. Just be aware of their limitations with regard to size, spacing, and quality (anti-aliasing).
- **GEM fonts**—GEM fonts also work well for all arcade text purposes. However, like ZSoft fonts, they tend to be limited in terms of size, spacing, and quality.
- **Fastgraph fonts**—Fastgraph fonts are useful for all arcade game text purposes. They suffer the same problems as ZSoft and GEM fonts but offer more flexibility due to their ability to control their spacing via software.
- **Custom bitmapped**—Custom bitmapped fonts can be used for any arcade game text application. They can be especially effective for titles. Just make sure that the fonts used are legible. However, be aware that the widespread availability of Windows and Macintosh TrueType fonts often negates their usefulness.
- **Borland Stroked fonts**—These fonts are useful for title text but not much else. Despite being scaleable, their quality and legibility is usually lacking at all but the largest sizes.
- **TrueType fonts**—TrueType fonts are the most flexible of all of the font formats mentioned here. They can be used to render any game text and should be used over the other font formats whenever possible.

Table 10-14 provides a list of recommended TrueType fonts to use in your game projects. The fonts listed here are available from a variety of sources. Some are commercial, some are pre-installed on most systems, but most are from freeware or shareware sources. In addition, the Internet offers one of the best selections of fonts. The supporting Web site for this book, `http://www.gamegfx.com` has a listing of some of the best sites for downloading fonts.

NOTE: Check on the legality of any font you download from the Internet. As it happens, many commercial fonts are repacked as being free or shareware when they are not.

TABLE 10-14: TrueType Game Font Recommendations

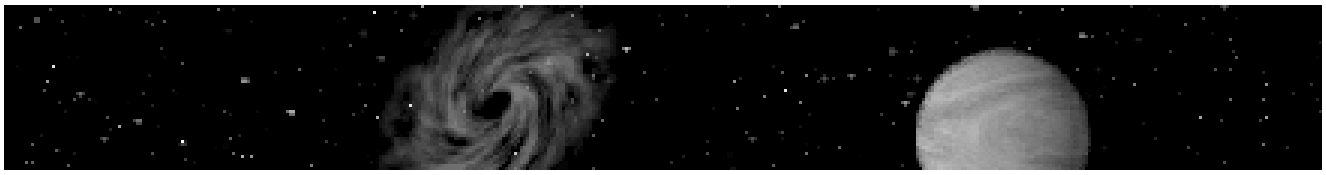
Common Font Face	*Font Characteristics*	*Potential Use(s)*	*Availability*	*Comments*
Ameila	Proportional, sans serif, decorative	Game titles, status indicators	Freeware or shareware	A good "computer terminal" style font. Useful for arcade games with futuristic themes.
Apple Garamond	Proportional, serif, non-decorative	Game titles, body text, status indicators	Commercial	The Apple "Think Different" font. Recommended for when you want to portray a sense of elegance and sophistication in your game while maintaining readability.
Arial	Proportional, sans serif, non-decorative	Game titles, body text, status indicators	Pre-installed	An excellent all-around arcade game font.
Arial Black	Proportional, sans serif, non-decorative	Titles, status indicators	Pre-installed	A particularly good font for rendering large titles.
BattleStar	Proportional, sans serif, decorative	Game titles	Freeware or shareware	A font patterned after the old *Battlestar Galactica* TV series. Useful for arcade games with futuristic themes.
Beatsville	Proportional, sans serif, decorative	Game titles, body text, status indicators	Freeware or shareware	An excellent font for retro- and cartoon-style arcade games.
Bedrock	Proportional, sans serif, decorative	Game titles, status indicators	Freeware or shareware	An excellent font for arcade games with prehistoric themes.
Broadway	Proportional, serif, decorative	Game titles, status indicators	Freeware or shareware	An interesting Art Deco styled font. Recommended when you want to portray a sense of nostalgia in an arcade game.

Common Font Face	*Font Characteristics*	*Potential Use(s)*	*Availability*	*Comments*
Bullet Holes	Proportional, sans serif, decorative	Game titles	Freeware or shareware	Interesting title font that's good for military-style shooters.
Carrkeys	Proportional, sans serif, decorative	Status indicators	Freeware or shareware	Very useful for rendering keyboard command keys.
Celtic	Proportional, serif, decorative	Titles, body text	Freeware or shareware	Recommended for all medieval-style arcade games.
Century Gothic	Proportional, sans serif, non-decorative	Game titles	Commercial, freeware, or shareware	An excellent font for creating easy-to-read yet sophisticated-looking titles.
Comic Sans MS	Proportional, sans serif, decorative	Game titles, status indicators	Installed by many Microsoft software products	Useful font for cartoon-style arcade games.
Courier New	Monospaced, serif, non-decorative	Game titles, body text, status indicators	Pre-installed	Useful font for retro-style arcade games because of its resemblance to terminal fonts used on old computers.
Franking Gothic	Proportional, sans serif, non-decorative	Game titles, status indicators	Commercial	An excellent all-purpose arcade game font.
Futura Light	Proportional, sans serif, non-decorative	Game titles	Commercial	An excellent font for creating easy-to-read yet sophisticated-looking arcade game titles.
Humanst521	Proportional, sans serif, non-decorative	Game titles, body text, status indicators	Commercial	An excellent font for creating easy-to-read yet sophisticated body text.
Joystix	Monospaced, sans serif, non-decorative	Body text, status indicators	Freeware or shareware	An excellent replica of a classic arcade game machine font. Very useful for retro-style arcade games.

Common Font Face	*Font Characteristics*	*Potential Use(s)*	*Availability*	*Comments*
Jurassic	Proportional, sans serif, decorative	Game titles, status indicators	Freeware or shareware	An excellent font for arcade games with prehistoric themes.
Mandarin	Proportional, serif, decorative	Game titles, body text, status indicators	Freeware or shareware	A great font for arcade games with oriental themes.
Old English	Proportional, serif, decorative	Game titles, status indicators	Freeware or shareware	Recommended for all medieval-style arcade games.
Serpentine	Proportional, sans serif, decorative	Game titles, body text, status indicators	Freeware or shareware	Useful for arcade games with futuristic themes.
Star Base Normal	Proportional, sans serif, decorative	Game titles	Freeware or shareware	A *Star Trek*-style font. Useful for arcade games with futuristic themes.
Stencil	Proportional, sans serif, decorative	Game titles, body text, status indicators	Freeware or shareware	Interesting title font for arcade games with military themes.
Times New Roman	Proportional, serif, non-decorative	Game titles, body text, status indicators	Pre-installed	Recommended when you want to portray a sense of elegance and sophistication while maintaining readability.
Toontime	Proportional, sans serif, decorative	Game titles, status indicators	Freeware or shareware	An excellent font for retro- and cartoon-style arcade games.
Verdana	Proportional, sans serif, non-decorative	Game titles, body text, status indicators	Installed by Microsoft Internet products	An excellent all-purpose arcade game font. This font was developed specifically for displaying readable text on the computer screen.

NOTE: Due to vast differences in font naming conventions, it is entirely possible for the same font to go under two or three different names.

NOTE: The book's accompanying CD-ROM contains a number of useful freeware and shareware fonts, including several of the fonts described in Table 10-14.



Chapter 11

Planning Arcade Game Graphics

In this chapter, you'll learn about:

- **Planning your arcade game graphics**
- **The game summary**
- **The game action sequence**
- **The graphics specification**
- **Technical restrictions**
- **The game glossary**

Behind every successful arcade game project stands a well-crafted plan. This being said, before you plot even a single pixel, you should take the time to plan out every aspect of your game's artwork from its appearance to how the individual elements and objects will interact with each other when displayed on-screen. Simply put, creating a detailed plan at the start of each new game project will save you time and effort, reduce mistakes, and improve the overall quality of the artwork that you create.

The Design Plan

Let's take a look at the *design plan*, or the document that details and records all of the creative-related issues that are associated with your game. An effective and well-written design plan will include most, if not all, of these elements:

- Game summary
- Game action sequence
- Graphics specification
- Technical restrictions and stipulations
- Project schedule
- Game glossary

Before continuing, it's important to realize that the extent to which you adhere to these elements in your own game design plans really depends on the size and sophistication of the game project at hand. Larger games should include all of these items, while smaller games can omit one or more of these steps. Use your best judgment here, especially if time is an issue. There's no reason to craft a full-blown design plan for a really simple game. At the same time, however, you're only hurting yourself if you skimp on these details for a big game project.

NOTE: The purpose of this chapter is to point you and/or your development team in the right direction regarding how you want the game to look and work—nothing more. The last thing I want to do is dictate how something must be done. After all, what works for me might not work for you.

The Game Summary (required)

The game summary provides a general overview of the game in question. The purpose of this part of the design plan is to get you thinking about the look of the game as early as possible in the design process. Since the game summary serves as the foundation of your design plan, it should be comprehensive but not overly detailed; use the other sections of the design plan to really get into specifics and fill in any gaps that might develop.

It should include these elements:

- Game back story
- Game description
- Game object inventory
- Game functionality overview

Game Back Story (optional)

This section provides the basic background story for your game.

Generally speaking, the back story doesn't have any direct influence on the game except to make it seem more interesting to the player; therefore, you can leave it out if you want.

In terms of size, it can be as descriptive or as vague as you want. It's really up to you.

Example:

```
The year is 2299 and you've just arrived to assist in the asteroid
sweeping operation along the frontier.

You volunteered for this duty in the hopes of avoiding long-term military
service on some alien-infested world. You thought it would be easy. Well
buddy, it looks like you were wrong…
```

Game Description (required)

The purpose of this section is to summarize and explain the overall theme, function, and mechanics of your game. This section is required because without a game description, no one will have any idea what your game is about!

Try to limit the length of this section unless there's a particular need to go into more detail. One or two short paragraphs should be sufficient.

Example:

```
Disasteroids is an "asteroids"-style arcade game in which the player
maneuvers a small spaceship through a dangerous planetary asteroid field.
The player scores points by shooting at and destroying these asteroids. At
the same time, the player must avoid dense bands of roving asteroids,
fast-moving asteroid fragments, and other perils including belligerent
alien spaceships and mines.

The asteroids that appear are all randomly generated; however, each game
level assigns a specific number of asteroids to be destroyed called a
quota. After all of the asteroids on a given level are eliminated, the
player is automatically transported to the next one.
```

Game Object Inventory (required)

This section is used to list and describe all of the game's objects from background images to text elements. Each object description should include pertinent information on object properties such as size and color, as well as any associated actions or movements. Doing this not only helps you get a better sense of the game's objects, but should help anyone else involved with the project as well.

The object inventory list should be as thorough as possible, but you should try to keep the individual object descriptions brief. Two or three sentences per object should be more than enough at this stage. Later, once you have a better sense of the various game elements, you can add more.

Examples:

- **Player Ship**—A round, metallic spacecraft that is controlled by the player. The player's ship is equipped with a blaster cannon that shoots various types of energy projectiles and it can move in all eight directions.
- **Arian Magnetic Mine**—A small, metallic, slow-moving object that drifts randomly across the game screen. It will be completely vaporized when it collides with another object (except another mine).

NOTE: You may also find it helpful to include rough sketches of the different game objects mentioned here. You can place them on a separate page or simply draw them alongside each object's entry. Doing this can help you and other development team members to get a better handle on what you're thinking regarding the objects you're designing. It might also help eliminate any *dead-end* artwork, or art that doesn't quite fit the feel of the game, before things go too far.

Game Functionality Overview (required)

The purpose of this section is to define the game's desired functionality. It should consist of a simple, bulleted list.

Example:

- Runs on any Pentium-based PC running Windows 95, 98, or NT 4.0.
- Offers 10 increasingly difficult levels of play.
- Includes a special arcade "Classic" mode with eight levels of play.
- Battle four types of asteroids, alien spacecraft, minelayers, and mines.
- Obtain weapon power ups and extra lives.

The Game Action Sequence (required)

The game action sequence is essentially a storyboard that details the various screens needed to play the game, the order in which they appear, and the various attributes and actions associated with them. All arcade games include two types of game screens: *functional screens* and *play screens*.

Functional screens are screens that contain game-related information, control, and configuration options. This includes title/introductory screens, menu/option screens, transitional/cut-scene screens, help screens, credits screens, and game over screens.

Play screens are any screens where game activity occurs; in other words, they are the actual game levels.

The game flow sequence consists of three parts:

- The game action flowchart
- The screen summary
- Screen mock-ups

The Game Action Flowchart (required)

This is a diagram that illustrates the basic flow of action within the game. It can range from something as crude as a piece of loose-leaf paper with hand-drawn flow diagrams to something very sophisticated that was produced with a professional-quality flowcharting package. Either is fine as long as they include information about the various paths of action that can occur in the game.

NOTE: Whenever possible, use flowcharting software to create these diagrams. Such programs allow you to make changes easily and will give you flexibility when it comes to printing and sharing the information with others. To help you with this, I've included a trial copy of *WizFlow* flowcharting software on the book's accompanying CD-ROM. See Appendix B for more information on this program.

Example:

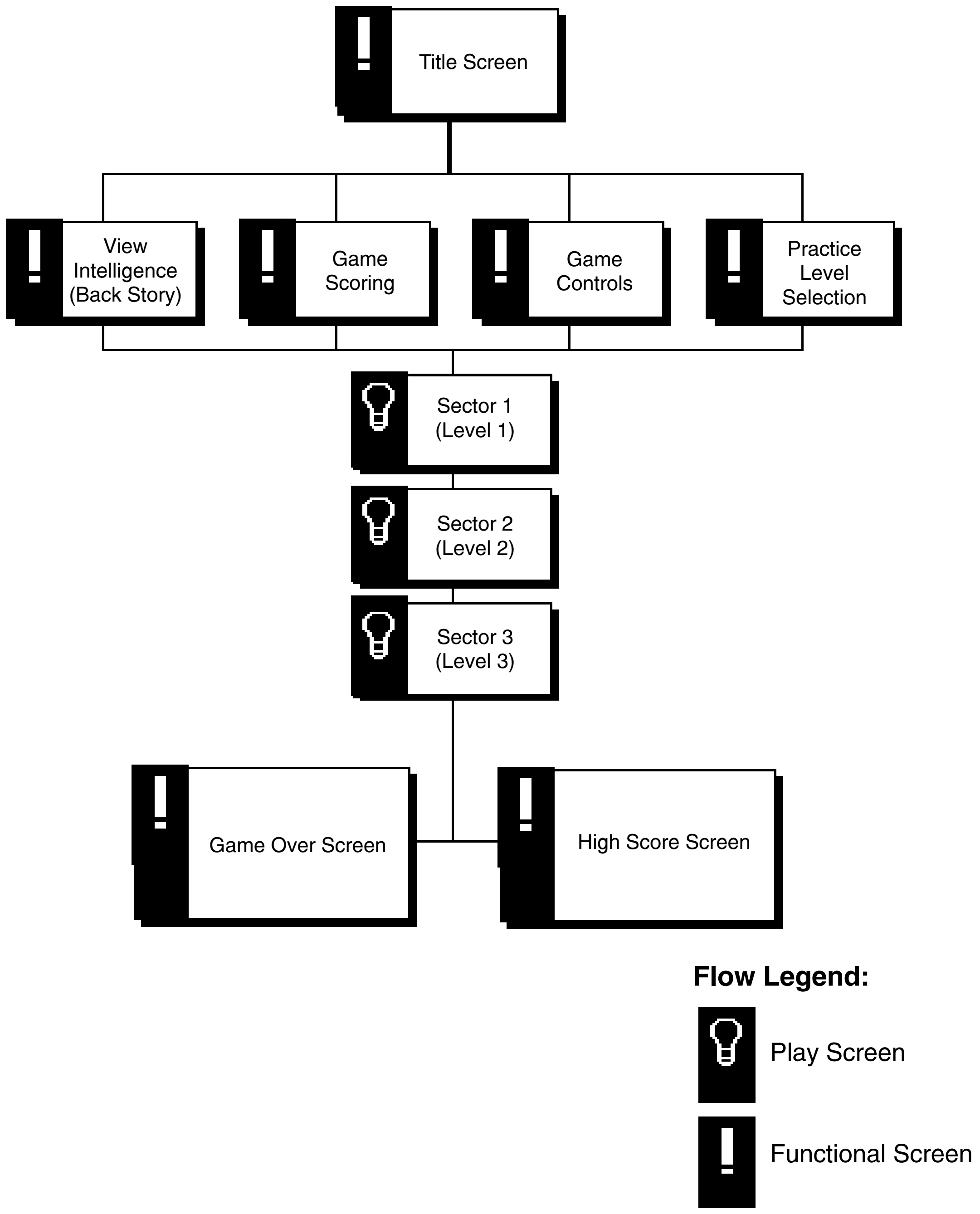


FIGURE 11-1: Example of Game Flow Sequence

The Screen Summary (required)

The screen summary should include a brief description of what each screen does along with a rough, general description of the various objects that may appear on it and any actions it supports.

In terms of length, for now, one or two short paragraphs per game screen should be enough.

Examples:

```
Title Screen

This is the screen that the user sees upon starting the game. It contains
the program's title, credits, copyright information, and menu elements
from which the player can access different game options.

Available Game Actions:
■ Play a game (go to level one)
■ View game controls (go to the Game Controls screen)
■ View game scoring (go to the Game Scoring screen)
■ View game help (go to the View Intelligence screen)

View Intelligence Screen

This screen is the game's main information screen. Among other things, it
provides the player with some of the game's back story as well as a
summary of the different game elements and tips on how to deal with them.

Available Game Actions:
■ Play a game (go to level one)
■ View game controls (go to the Game Controls screen)
■ View game scoring (go to the Game Scoring screen)
```

Screen Mock-ups (required)

This section should include illustrations, sketches, or diagrams of each game screen in order to help you to better visualize how each game screen will look.

Whenever possible, it is highly recommended to graphically mock up each screen since better visuals result in less confusion and give everyone concerned a much clearer idea of what each screen will look like. However, if you're lazy and/or just pressed for time, rough sketches can usually work just as well.

In completing this section, it's also good practice to label your objects and map them back to your object inventory list.

Examples:

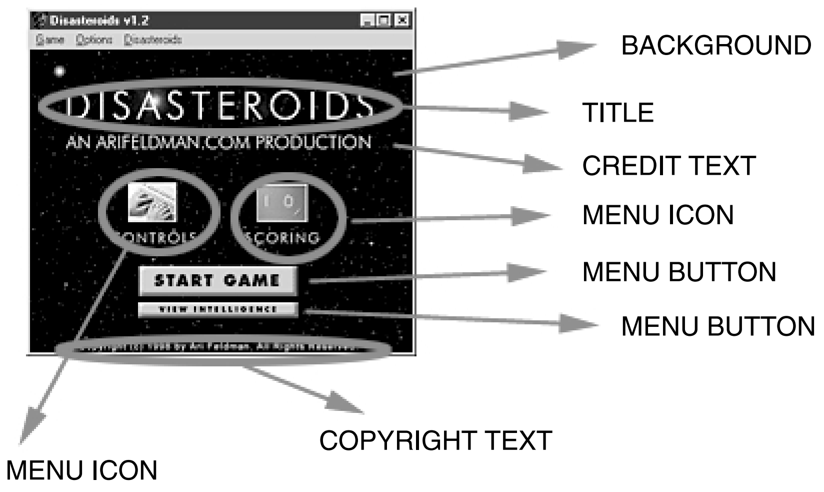


FIGURE 11-2: The Title Screen

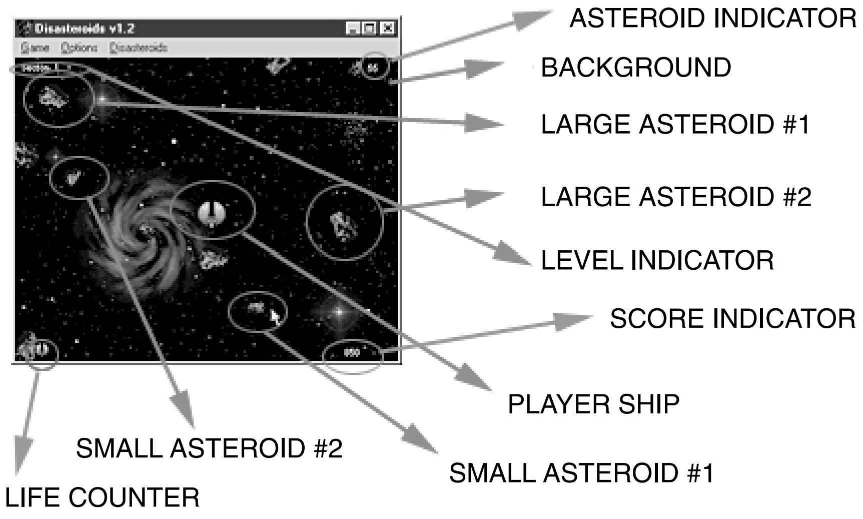


FIGURE 11-3: The Main Game Screen (Levels 1-3)

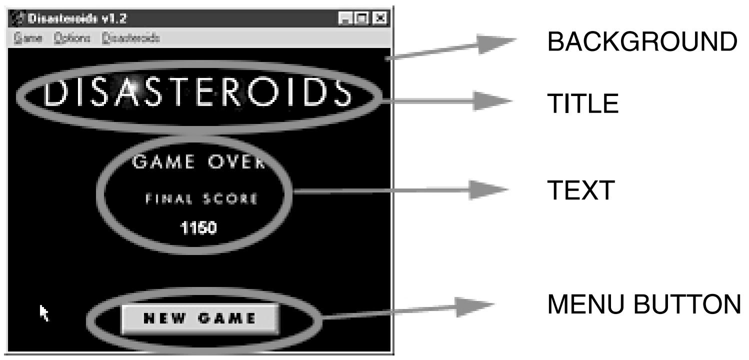


FIGURE 11-4: The Game Over Screen

While this seems like a lot of work (and it often is) to include such screens in your design plan, the contents of this section are crucial to the design process. Without them, you won't have a visual record of how each game screen will look, work, or tie together.

NOTE: Most of the programs mentioned back in Chapter 6 are excellent for this purpose.

The Graphics Specification (required)

The graphics specification details the graphic elements needed for the game in question. Specifically, it should contain such information as:

- Game creative statement
- Artwork orientation
- Target platform
- Estimated object count
- Artwork screen resolution and playfield size
- Artwork color depth
- Artwork file format(s)
- Artwork filenaming scheme
- Artwork color palette
- Artwork gamma level
- Artwork object dimensions
- Frames per object

- Object actions and facings
- Game text font(s)
- Miscellaneous art direction

For obvious reasons, the graphics specification section is the largest and most important part of your design plan. Not only will you rely on it, but so too will the other members of the development team. Therefore, it's crucial that you make this area as detailed as possible in order to avoid any misunderstandings between team members and to ensure that you get the results you want.

Game Creative Statement (required)

This is a creative statement that describes the overall style, feeling, and personality expected of the artwork (i.e., realistic, cartoon-like, happy, gloomy, dark, serious, etc.). The statement should be concise yet sufficiently descriptive to get the point across. Two to three sentences should be more than adequate for this purpose.

Example:

> The artwork in *Disasteroids* will be hyper-realistic in style. All objects will appear as detailed as possible and will be rendered using colors that support this effect to the fullest.

Artwork Orientation (required)

This section describes the physical orientation and perspective of the artwork (i.e., above-view, profile-view, etc.). All that is necessary is a brief, one- or two-sentence statement.

Example:

> *Disasteroids* will employ an above-view perspective. In other words, all game objects will be rendered as if the light source is shining directly above them.

NOTE: It might help to include a few simple sketches of objects rendered in the described orientation in order to illustrate the concept.

Target Platform (required)

This section simply describes the intended target platform of the game. It's important to include this information since it can influence the RGB values selected for the palette as well as the file formats used to store the associated game artwork.

NOTE: It's also necessary to mention the target platform just in case this information wasn't originally included in the design plan's game summary section.

Example:

```
Disasteroids is intended to run on all Windows 95, 98, and NT 4.0 systems.
```

Estimated Object Count (required)

This section provides an estimated count of the overall number of graphical objects (sprites and backgrounds) that will need to be designed and created for the game. The object must match the game object inventory described earlier in the design plan.

NOTE: Since the game is still in the planning stage, the object count is not definitive. You may find yourself adding or removing game objects as your design plan evolves.

Example:

```
It's estimated that Disasteroids will require a total of 35 different
graphic objects to be designed and produced.
```

Artwork Screen Resolution and Playfield Size (required)

This section details the recommended or desired screen resolution in which to create the game's artwork (i.e., 320x240, 640x480, etc.) and the size of the game's play area.

NOTE: This information should only be included here after an initial consultation with a programmer. This is due to potential technical issues that might crop up when using a particular screen resolution.

NOTE: The playfield size usually only applies to systems that using a windowing operating system. Therefore, it wouldn't be defined for a game that's intended to run on DOS. It can also be left blank if you indicate that the game will run fullscreen, i.e., DirectX 640x480 fullscreen, etc.

Example:

```
All of the artwork in Disasteroids will be created in a screen resolution
of 640x480.
```

```
Disasteroids will use a screen window that is 400x380 in size. This will
remain constant for ALL game screens, regardless of their type.
```

Artwork Color Depth (required)

This section describes the color depth that the game's artwork will be created in (i.e., 16 colors, 256 colors, thousands of colors, etc.). Among other things, the information provided here will help the programmer determine whether or not certain special color effects are possible.

NOTE: This information should only be included here after an initial consultation with a programmer. This is due to potential technical issues that might crop up when using a particular color depth.

Example:

```
All of the artwork in Disasteroids will be designed in 256 colors (8-bit
color).
```

Artwork File Format(s) (required)

This section details the preferred or acceptable file format(s) to store all of the artwork in (i.e., BMP, PCX, etc.).

This information should only be included here after an initial consultation with a programmer. This is done to avoid any potential technical issues that might crop up when using a particular file format.

Try to provide as much information here as possible, including listing any subformats of the selected graphics format. Including this information helps to flag any potential compatibility problems with your software.

NOTE: Be sure to be explicit in mentioning the selected graphics file format for each type of artwork screen you use. For example, you might choose to store your sprite screens in the BMP format but use TGA for your title screens.

Example:

```
All of the artwork in Disasteroids will be stored using 8-bit, RLE format
Windows BMP files.
```

Artwork File Naming Scheme (required)

This section details the file naming convention that you intend to use for your artwork. You should break out the naming scheme for all game object types separately. For more information on this issue, refer to Chapter 4.

Example:

Sprites:

- ani_player.bmp (main player)
- ani_alien.bmp (alien objects)
- ani_asteroids.bmp (asteroid objects)
- ani_effects.bmp (explosions, shots, and missile objects)
- ani_assorted.bmp (miscellaneous game objects such as title screen animations, etc.)

Backgrounds:

- bkg_level1.bmp (level one background)
- bkg_level2.bmp (level two background)
- bkg_level3.bmp (level three background)

Other:

- mnu_buttons.bmp (buttons for menu and help screens)
- mnu_assorted.bmp (miscellaneous menu screen objects)

Artwork Color Palette (required)

This section describes the preferred color palette(s) to be used in the game. This information should include a complete list of RGB values, the transparent color value, and any reserved or off-limit palette entries. You may also opt to include palette format information if the programmer requires you to supply the color palette in a separate file.

NOTE: Be sure to provide all palette definitions using this format: `palette entry: RGB value`. For the transparent color and the off-limit/reserved colors, you only need to provide the palette entries affected.

Example:

Color Palette Definitions:

```
Index: R,   G,   B
  0:   0,   0,   0
  1: 128,   0,   0
  2:   0, 128,   0
  3: 128, 128,   0
```

```
 4:   0,   0, 128
 5: 128,   0, 128
 6:   0, 128, 128
 7: 192, 192, 192
 8: 192, 220, 192
 9: 166, 202, 240
10: 255, 219,   0
11: 219, 167,   0
12: 183, 127,   7
13: 147,  87,   7
14: 111,  59,   7
15:  75,  35,   7
16: 255,  11,  15
  .   .    .    .
  .   .    .    .
```

Transparent Color: Index 254 (RGB: 0,0,0)

Off-Limit or Restricted Colors:

None aside from the normal 20 Windows reserved system colors.

Other:

- There are no palette entries reserved for color cycling.
- Palettes will also be supplied as Microsoft .PAL files.

Artwork Gamma Level (required)

This section lists the gamma level at which the graphics will be created.

NOTE: This information can be important, especially if the artwork is created on a different platform than the game's target system, i.e., you design the graphics on a Macintosh while the game is slated to run on Windows.

Chapter 2 provides more information on estimating the gamma level for your particular system or platform.

Example:

The graphics for *Disasteroids* will be designed on a Windows PC using a gamma level setting of 2.2.

Artwork Object Dimensions (required)

This section lists the maximum and/or recommended pixel dimensions (grid square size) for all sprites and background images.

NOTE: This information should only be included here after an initial consultation with a programmer. This is due to potential technical issues that might crop up when dealing with certain development tools that might require game objects to be created in certain sizes.

Examples:

- `Sprite Grid Square Dimensions: 64x64`
- `Background Image Dimensions: 400x380`

Frames per Object (required)

This section details the number of frames of animation required for each game object. It's important to record this information in order to estimate how long it might take you to create the artwork for a given game. This information also helps you determine how smooth or coarse the individual animations for each object will be.

Refer to Chapter 9 for more information on animation frames.

Examples:

- **Player Sprite:** moving (2) - Total Frames: 2
- **Asteroid Sprite:** moving (8) - Total Frames: 8
- **Explosion Sprite:** exploding (13) - Total Frames: 13
- **Warp Signature Sprite:** warping (8) - Total Frames: 8

Object Actions and Facings (required)

This section describes all of the potential actions that each game object (sprite) will perform in the game (i.e., walking, running, shooting). As part of this information, you should include the number of facings that each game object requires (i.e., left, right, top, bottom). It's important to record this information in order to estimate how long it might take you to create the artwork for a given game.

NOTE: Try to be as detailed as possible with regard to this section and be sure to include the total number of actions for your records.

Example:

- **Player Sprite:** moving (8) - left, right, upper-left, lower-left, up, down, upper-right, lower-right

NOTE: You may find it helpful to indicate how each object facing maps to a specific game control. For example, you can include a sketch of a mouse movement, keyboard press, or joystick movement that produces each object facing.

Game Text Font(s) (optional)

This section describes the preferred font and text style to be used in the game (if applicable). Most games default to the currently active system font (i.e., 8x8, 8x16 if DOS or TrueType if Windows or the Macintosh, etc.). This information applies to both the fonts used for housekeeping tasks such as displaying the game's score and the font style that appears on the game's title and menu screens.

Always make sure you provide the exact font names for each font you use. Doing this will help minimize confusion during implementation.

Also, make distinctions between what should be rendered in graphic text (i.e., bitmapped font) and what should be rendered in system text. There's a huge difference in quality between the two and system text is usually not something that you can change since it's under program control.

Finally, be sure to include the X and Y pixel dimensions for each custom bitmapped font you intend to use as well as a list of all of the characters this font includes.

Examples:

- **Houskeeping Font:** *Disasteroids* will use 10-point, aliased Arial for all game screen indicators such as level and score.
- **Menu Screen Font:** *Disasteroids* will use 18- and 24-point, anti-aliased Futura for all graphic text.
- **Title Screen Font:** *Disasteroids* will use 12-point, anti-aliased Futura for all graphic text.
- **Custom Bitmapped Font:** 16x16 - includes A-Z, a-z, 0-9, and !$+-.,?()=:

Miscellaneous Art Direction (optional)

This section includes any additional art direction that was left out in the previous design plan sections.

NOTE: Due to the importance of the graphics specification section of the design plan, don't proceed any further if any required information is missing. Even missing a detail as small as the number of frames in animation required per sprite can throw a big wrench into the works of a game project. Also, never guess or make assumptions about any item mentioned here since you might guess wrong. If a certain piece of information is missing, track it down before proceeding. It may lengthen the design process but it helps reduce the likelihood of problems during the project. It is better to be safe than sorry!

Technical Restrictions and Stipulations (optional)

This section of your design plan discusses any technical restrictions imposed by the game and/or the development environment.

For example, this section might mention fixed sprite size limits or color use restrictions that have the potential to adversely impact how you create and implement your artwork. It's very important that this information be obtained and detailed as early in the project as possible before you start drawing your graphics! This is necessary because you don't want to create extra work for yourself in case some technical issue crops up that renders your artwork useless for the project.

Typically, the programmer would convey such information during the start of the project; therefore be sure you discuss any potential caveats with him or her if you're not actually coding the game yourself.

NOTE: This section is optional because there may not be any technical restrictions that apply to your particular game project.

Example:

In order to maximize screen performance on slower systems, no object in *Disasteroids* should be larger than 128x128 pixels in size.

The Project Schedule (optional)

Most game projects, including those that are done in one's spare time, have some sort of schedule associated with them. A schedule helps to introduce the element of order into what is often a chaotic process. Without a schedule that establishes firm *milestones*, or special project-related deadlines, your game project could potentially drag on forever. To prevent this, use a schedule to help you impose deadlines for yourself as well as for other members of your development team. A game graphics schedule might include such items as:

- The estimated start date for the project.
- An estimated date for presenting the initial game artwork to the game's programmer(s).
- An estimate for how long it will take to revise the artwork as per programmer/other team member feedback.

- An estimated date for delivering revised artwork to the game's programmer(s).
- An estimate for how long it will take to complete the remaining game artwork.
- The estimated end date for delivering the final artwork to the game's programmer(s).

As a game graphics designer, it's important to define milestones for the project early on in the process in order to establish good work habits and to facilitate the delivery of a timely game. Also, be sure to establish realistic milestones by giving yourself sufficient time to complete the designated task, as there's no sense having a deadline if you can't meet it.

You should always base your schedule milestones on realistic estimates. This means if you think it will take you at least two weeks to create the artwork and animation for a particular game, don't say you can do it in one week. Often, your estimates will be wrong, especially when working on your first few projects. Therefore, the best advice I can give you here is to overestimate. That means, if you think you can complete a project in two weeks, give yourself three weeks. This will give you some slack time in case you run into some unforeseen snags (and you will) while working on a project.

Schedules are an invaluable resource for medium to large scale game projects and are best created using a tool that allows easy revisions and modifications. For our purposes, any spreadsheet program or text editor should be enough to create and manage your schedule. However, if you're interested in a more scaleable and robust solution, then I recommend using professional project management/schedule software such as *Microsoft Project* or *IMSI's Turbo Project* series.

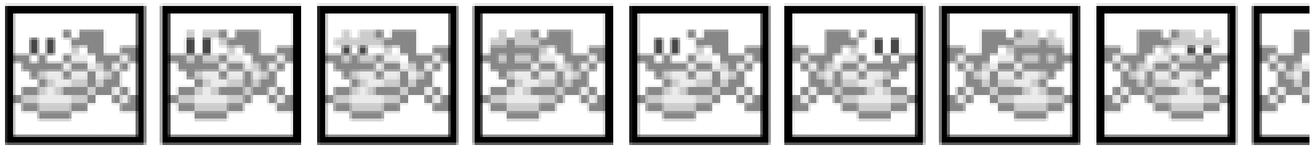
In closing, remember that schedules are just estimates. This means that they can be adjusted. Don't be afraid to do so as long as you inform the other members of your development team about changes in the schedule so that they can make adjustments on their end. Hopefully, you won't make many adjustments as the original schedule you created was done with achievable deadlines. Still, at least you have the option to do so.

NOTE: This section is optional, especially if you develop games strictly for your own pleasure. However, even then you might want to use one anyway since it might give you the incentive to actually finish a project for a change!

The Game Glossary (optional)

The purpose of the game glossary is to tie up any remaining loose ends by defining the terms and vocabulary introduced in the design plan. Essentially, it serves as the development team's "rosetta stone" as it allows all team members to get on the same page regarding the terminology used for all of the game's characters, objects, and events.

It's generally considered good practice to include a glossary at the end of each section if you introduce a lot of unique terms. This will help to minimize any confusion over terminology that carries over into other sections of the design plan. However, as design plans vary, feel free to place the glossary section where you best think it should go. The end of the design plan will suffice for most game projects.



Chapter 12

Hands-on Arcade Game Project—*Fish Dish*

In this chapter, you'll learn about:

- **Planning an actual game project**
- **Designing an online arcade game**
- **Designing simple sprites**
- **Designing simple backgrounds**
- **Designing simple title screens**

For much of the last 11 chapters, this book has focused almost exclusively on the theory, tools, and technology behind creating arcade-style game graphics. Now it is time to take what you have learned up to this point and apply it to a real game project. Therefore, in this chapter, we will actually conceive, spec, and design the artwork and animation for a maze/chase game called *Fish Dish*.

Fish Dish is an arcade game in which you control a small fish that must eat other fish to grow while at the same time avoiding becoming the meal of a larger fish.

The simple nature of this game makes it the perfect platform for discussing a variety of important game design topics, including:

- Basic online game design
- Establishing an artwork style
- Optimal color selection and usage
- Understanding graphics orientation
- Game character design
- Title and background screen design

Getting Started

Before proceeding with the *Fish Dish* tutorial, please be aware that this chapter makes extensive use of previously discussed concepts. Therefore it is suggested that you familiarize yourself with topics such as *color theory*, covered in Chapter 7, *color palettes*, covered in Chapter 8, *sprites and animation*, covered in Chapter 9, and *planning*, covered in Chapter 11.

Moreover, this chapter also assumes that you are comfortable with the graphics creation tools discussed in Chapter 5. Specifically, this chapter assumes that you fully understand how and, more importantly, when to use:

- The Pencil tool
- The Brush tool
- The Line tool
- The Smear tool
- The Fill tool
- The Zoom tool
- The Selection tool (including Cut, Copy, Paste, and Flip operations)
- The Lasso tool (including Cut, Copy, Paste, and Flip operations)
- The Color Selection tool
- The Eye Dropper tool

NOTE: This tutorial was designed to be application agnostic. In other words, all of the tips, tools, and techniques described in this chapter should work regardless of the actual graphics software being used.

The Three Phases of *Fish Dish*'s Design

To make it easier to follow, the *Fish Dish* design tutorial is divided into three phases. These are:

- **Phase I: The design analysis**—During this phase, we examine the game's concept, identify important design and technical issues, and discuss how to arrive at a suitable design plan. The purpose of this phase is to develop a solid approach to the game's design and gain a better understanding of the overall issues and problems that might occur over the course of the game's graphic development.
- **Phase II: The design plan**—During this phase, we document and organize all of the game's various components. The purpose of this phase is create a master document that will serve as a reference and road map for the rest of the graphic design process.
- **Phase III: The design execution**—During this phase, we actually implement the game's artwork and animation according to the principles and specifications laid out by the previous two phases. This is the most involved section of the tutorial and where you get to see how the various elements in a game are created and fit together.

All three phases are interdependent and as such, no single phase can really exist or occur without the others. Skipping one or more of these phases may shorten the design time required by a game but does so only at the risk of introducing a number of problems in the process.

Phase I: The *Fish Dish* Design Analysis

The purpose of the *Fish Dish* design analysis is to identify the most important issues that can negatively impact the successful design and implementation of the game. As such, there are several design issues to consider and resolve. These include:

- Differentiating game objects
- Choosing a design style
- Characterization
- Online game issues
- Determining the order of element creation

Once a solution to each of these is determined, we can safely proceed to Phase II.

Differentiating Game Objects

Practically all arcade-style games, including *Fish Dish*, require the player to control an on-screen character, which must avoid a variety of other on-screen objects and obstacles in order to achieve a certain goal.

One of the biggest problems such games face is the player's ability to easily tell the game objects apart. In many cases, the problem is so bad that the player often has trouble recognizing and locating the on-screen character he or she is supposed to control! This situation results in general player confusion and makes the game unnecessarily difficult to play.

Although this is a potentially serious problem, it is surprisingly easy to avoid. The secret to preventing it is through the correct use of what designers call *differentiation devices*. Differentiation devices are simple graphical cues that can help game players distinguish between different game objects. It is the graphic designer's responsibility to add these cues to the game, which is why they are mentioned here. The most common differentiation devices are:

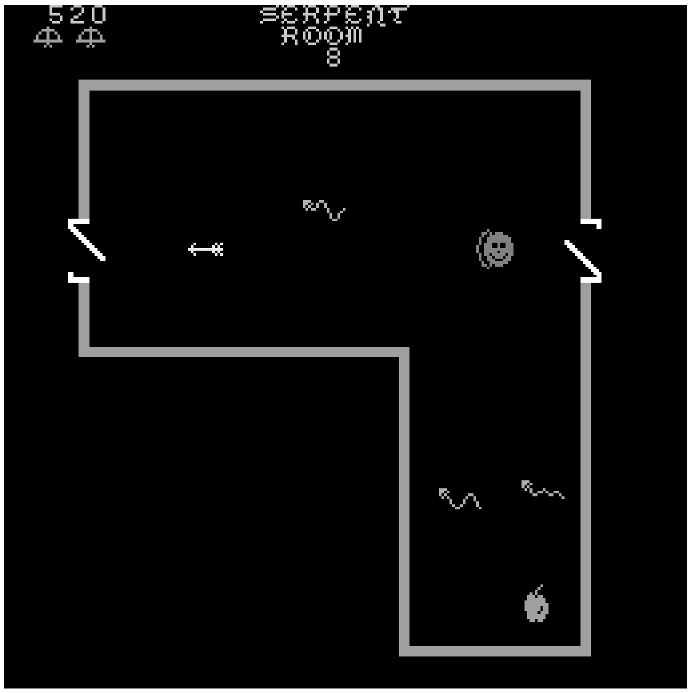
- Size
- Shape
- Color
- Position
- Animation

Size

Size is a popular method of differentiating game elements. Size works well in this role because it has the unique property of emphasizing the importance of one object over another. This is because most people instinctively assume that a larger object is more important in a game than a smaller object or vice versa.

For example, consider Figure 12-1. Notice how size is used as a differentiation device. In this scene, the circle object represents the player's on-screen character. Because it is up to twice the size of any other object on the screen, there is little doubt in the player's mind which object he or she controls.

A secondary use of size as a differentiation device is to increase the visibility of certain objects. This is because size can make specific objects easier or more difficult to see on the screen, depending on how it is used and applied.



Venture™

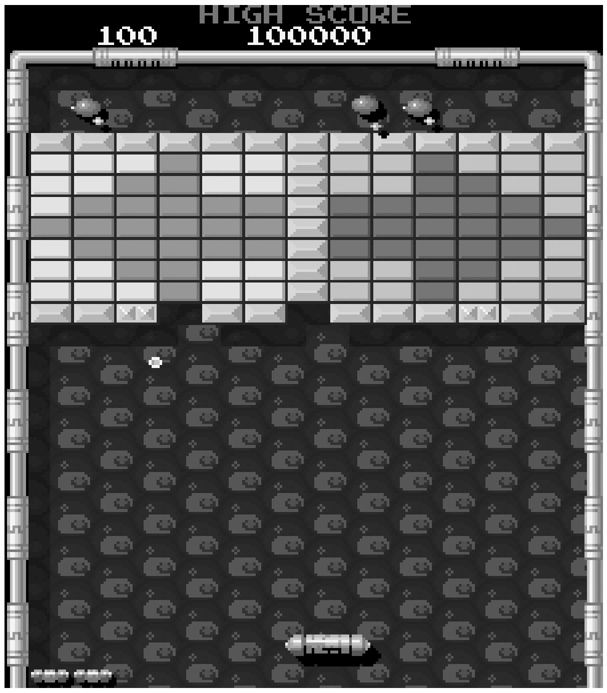
FIGURE 12-1: Example of Size as a Differentiation Device

Shape

Shape is another device we can use to differentiate between objects within a game. Shape helps players to visually establish a relationships between objects. Objects with similar shapes are assumed to have the same function or importance within a game. Meanwhile, objects with different shapes make it much harder for the player to make such associations.

A secondary use of shape is to make objects easier to recognize on a crowded game screen. For example, objects with distinctive shapes tend to stand out more than those with regular ones.

Finally, shape can help players better determine the form and function of a particular object. Consider the game pictured in Figure 12-2. In this game, the paddle's unique shape provides the player with important visual cues as to its purpose within the game.



Arkanoid™

FIGURE 12-2: Example of Shape as a Differentiation Device

Color

Color is one of the best ways to differentiate game elements. As mentioned in Chapter 7, color has several unique and powerful properties. The properties can be used to great effect in identifying and separating objects on the game screen.

First, we can use color to attract and focus the player's attention, which can be used to direct the player's eyes to specific objects. Second, color can be used to classify specific game objects either by their function or by importance. Finally, it can help to speed up the player's ability to search and recognize different objects.

Figure 12-3 shows how color can be used to distinguish between different game objects. In this example, the bright object at the bottom of the screen is the player-controlled character. Notice how this object stands out when compared to the other game elements. Not only does this maximize the object's visibility to the player but it also serves to reinforce its role and importance to the player within the context of the overall game.

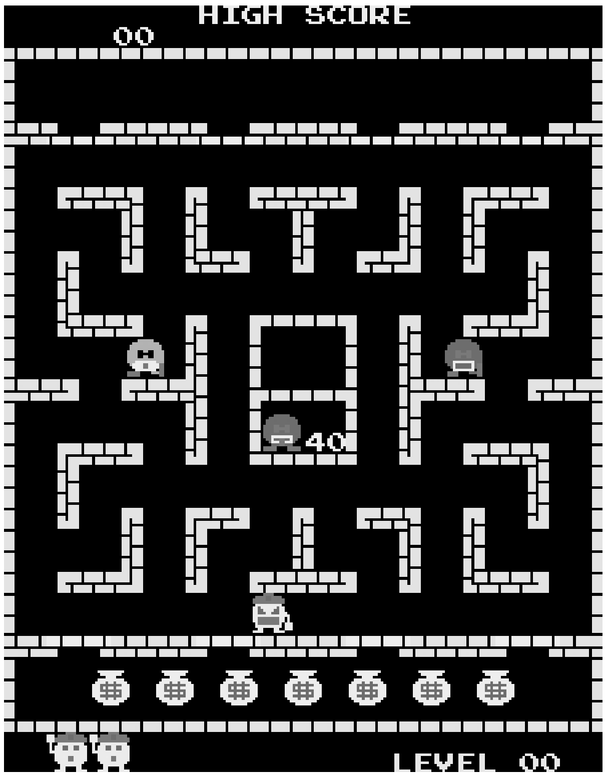
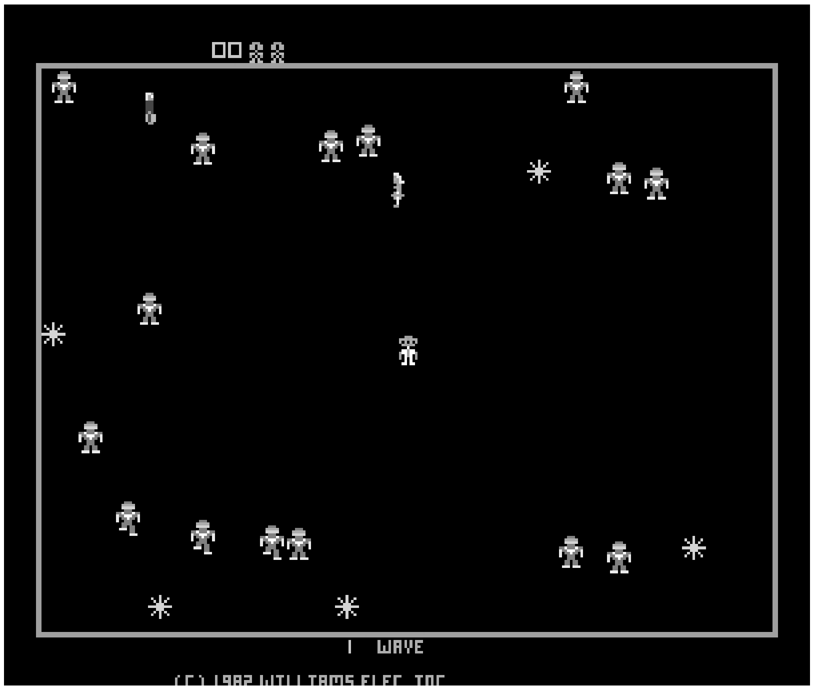


FIGURE 12-3: Example of Color as a Differentiation Device

Position

Position can also act as a differentiation device. In many arcade games, important objects are often positioned at specific sections of the screen to emphasize their importance or function. This is done for two reasons. First, placing objects at certain areas of the screen, especially the sides, corners, or center, ensures that they are inside the player's field of vision and hence are always seen. Second, the position of an object helps to emphasize its relationship with other objects. For example, objects that are close together give the appearance of being related and vice versa.

Figure 12-4 shows how position can be used to differentiate objects. In this example, the player-controlled character always starts a new game level positioned at the screen's center. Doing this places the object directly inside the player's field of vision, which ensures that the object is noticed. It also helps the player recognize the importance of the object since it is visibly separate from the rest.



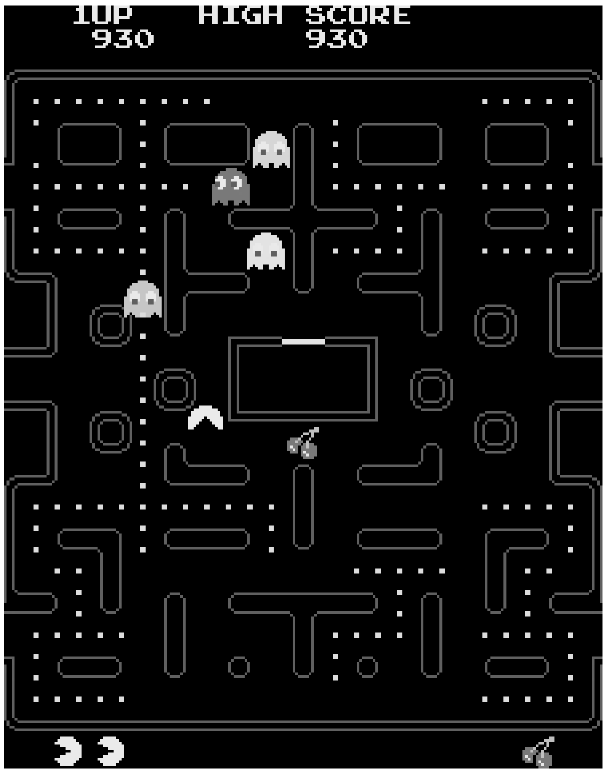
Robotron 2084™

FIGURE 12-4: Example of Position as a Differentiation Device

Animation

Animation is the last and one of the most powerful differentiation devices available to us. People naturally notice any object that is blinking, vibrating, pulsating, or otherwise dynamically changing. In games, these actions direct the player's eyes and provide important graphical cues as to the significance, function, and purpose of a given game element.

For example, the player-controlled character in Figure 12-5 is constantly moving. Visually, this serves as a clue to its importance, draws the player's attention, and clearly distinguishes it from the other on-screen characters.



Pac-man™

FIGURE 12-5: Example of Animation as a Differentiation Device

Table 12-1 summarizes the various differentiation devices that are available to us.

TABLE 12-1: Differentiation Device Summary Matrix

Differentiation Device	*Effects on Player*
Size	Players are more drawn to larger objects over smaller ones because they are easier to see on the screen. Similarly, players tend to equate the importance of an object with its size, so they logically assume that a larger object is more important than a smaller one.
Shape	When objects have similar shapes, players tend to assume that they are similar in terms of importance and function. Players also tend to notice objects with unique or distinctive shapes over objects with common or simple shapes.

Differentiation Device	*Effects on Player*
Color	Players tend to associate objects with dissimilar colors as being different from each other. Players also find objects with dissimilar colors easier to identify and locate on-screen. Finally, objects with dissimilar colors tend to attract and hold the player's attention over long periods.
Position	Players tend to focus better on objects that are placed conveniently within their field of vision. In addition to making objects easier to see, the position of an object reinforces its importance and relationship to other objects.
Animation	Players tend to be drawn to objects that move over those that do not. This helps to focus the player's attention, emphasize the function of the object, and provide other visual clues as to the relative importance of the object in question.

Commentary: Differentiation Devices in Fish Dish

The best arcade games actually combine one or more of these differentiation devices to ensure that there is little or no chance for player confusion when distinguishing between game elements.

For *Fish Dish*, we used size, color, and position as differentiation devices. Table 12-2 describes how and why these properties were used in the game.

TABLE 12-2: Differentiation Devices to Be Used in *Fish Dish*

Differentiation Device	*Comments*
Size	The later levels of *Fish Dish* use size to differentiate between safe and dangerous game characters. Game objects that are small or equal in size to the player-controlled character are safe, whereas game objects that are larger than the player-controlled character are dangerous.
Color	Throughout *Fish Dish*, we use color to help the player visually distinguish between different game objects. In addition, the player-controlled character will be rendered in a distinctive color scheme to make it easier to locate and follow during the course of play.
Position	The player-controlled character is to be positioned at the center of the game screen in order to increase its visibility.

Choosing a Design Style

Most dictionaries define *style* as "a combination of distinctive features of artistic expression or execution characterizing a particular group, school, or era." Although Chapter 7 briefly touched on the concept of design style as it pertains to color use, this chapter will examine design style as it relates to the actual appearance of your artwork.

A design style is one of the most powerful tools at your disposal. It helps you to define the appearance, theme, and audience for your game. In addition, it gives your artwork life and conveys a range of emotions from fear to nostalgia in the player, which ultimately reinforces their interest.

This being said, the process of choosing a design style for your game artwork is not something to be taken lightly. The design style you choose can have a dramatic effect on the visual aspects of your artwork from the size and shape you give your objects to the colors you use. Furthermore, once selected, a design style must be consistently carried through and applied to all of your game's graphic elements; otherwise you risk undermining its power.

To help you determine which design style to use for your game project, this section of the chapter examines three of the most important stylistic factors:

- Audience and emotional appeal
- Visual characteristics
- Difficulty of implementation

Audience and Emotional Appeal

It is very important to realize that a game is just an idea until you define its style. As you may recall from Chapter 8, all arcade games generally fall into one of three design styles: cartoon, retro, and realistic. There are others but these tend to be variations of the three types mentioned. Each design style can give your game a different look and feel depending on the audience segment you are trying to reach and the general theme of the game. For example, are you trying to rekindle childhood memories with your game? If so, then consider designing your artwork using a retro style. Do you want to make your game funny? If so, then consider using a cartoon design style.

Tables 12-3 and 12-4 classify the three main design styles according to these facts. Such information is useful when trying to match up a game's design with a particular demographic group and game theme.

TABLE 12-3: Design Style Demographic Appeal Matrix

Style Type	*Adult Men (Ages > 21)*	*Adult Women (Ages > 21)*	*Young Men (Ages 12-21)*	*Young Women (Ages 12-21)*	*Primary Emotion(s) Associated with Design Style*
Cartoon		✓	✓	✓	Cute, friendliness, warmth, familiarity.
Retro	✓				Nostalgia, familiarity, simplicity.
Realistic	✓		✓		Realism, elegance, and seriousness.

Although it may not be your primary consideration, you should never ignore or underestimate the emotional connection the player has with a specific game style when deciding how your game will ultimately look.

NOTE: Please use this matrix as a general guide only. It is based on observations made of players of various types of arcade-style games. For example, games with cartoon-like design elements and styles tend to appeal to women who are often put off by computers and technology. Meanwhile, both adult men and young men seem to prefer games with realistic design styles because they mirror the world around them.

TABLE 12-4: Design Style Theme Matrix

Style Type	*Humor*	*Adventure and Fantasy*	*Science Fiction*	*Action*	*Horror and Mystery*
Cartoon	✓				✓
Retro	✓	✓	✓	✓	✓
Realistic		✓	✓	✓	✓

Visual Characteristics

In addition to their emotional and audience appeal, each of the three design styles is characterized by a unique appearance. For example, games that employ a realistic design style look elegant and tend to mirror reality. Such games feature artwork that is designed to support the player's belief system through a careful interplay of color, size, patterns, and general design quality.

Table 12-5 summarizes the visual characteristics of each arcade game style.

TABLE 12-5: Design Style Visual Characteristic Matrix

Style Type	*Visual Characteristics*	*Comments*
Cartoon	Tend to feature objects with large areas of solid color contained by sharp, defining border elements. Objects often seem "cute" or simplistic, and mirror elements from comics or television cartoons.	A properly executed cartoon-style arcade game can score big points with players due to its inviting visual appeal. Games with cartoon design styles tend to translate very well to the online world since the Java/Netscape palette actually provides the appropriate color schemes these games need.
Retro	Tend to feature objects with large areas of solid color and no border elements. Objects appear coarse, crude, and blocky, and mirror elements that appeared in video games during an earlier age.	A relatively risky design style to use for games for mass audiences since many users will perceive games rendered in this style to be of inferior quality after being exposed to the large numbers of realistic games. Games with retro design styles translate well online since they use relatively simple color schemes.
Realistic	Tend to feature objects with many small areas of color contained by light, defining border elements. Objects appear detailed and realistic, and mirror the elements that one sees in everyday life.	Many players will identify with realistic design style arcade games. However, at the same time, players may be overly critical of a game that fails to properly maintain an illusion of reality. Games with realistic design styles generally do not translate well online since the Java/Netscape palette color palette is too limited in terms of the colors it provides.

For obvious reasons, the visual elements of a game's design style are paramount to its success. Not only does it influence how the player sees and perceives your game, but it is often associated with quality as well. In fact, many games are considered to be good simply because they look good. However, this being said, it is crucial that you successfully execute whatever design style you choose. Otherwise, you risk disappointing players and alienating them from your game.

Difficulty of Implementation

One consideration that is seldom mentioned but just as important as emotional appeal or aesthetics is the difficulty associated with implementing a given arcade game design style.

Each design style requires a different competency level to implement. Far too often, designers over-reach their abilities and attempt to design games using a design style they are simply not skilled enough to handle. For example, many beginners attempt to create realistic-style artwork before they fully master basic artistic techniques. This results in subpar work and taints what might be an otherwise good game.

Table 12-6 rates each design style according to the relative difficulty and artistic skills required to implement it.

TABLE 12-6: Comparison of Design Style Implementation Difficulty

Style Type	*Relative Difficulty*	*Designer Skill Level*	*Comments*
Cartoon	Generally easy to implement but somewhat difficult to perfect.	Beginner to intermediate	Requires a firm knowledge of color, shape, and basic animation techniques.
Retro	Very easy to implement and perfect.	Beginner	Requires rudimentary artistic skills and animation techniques.
Realistic	Difficult to implement and very difficult to perfect.	Intermediate to advanced	Requires a complete mastery of color, shape, light, and shadow, and advanced knowledge of animation techniques.

With regard to implementing a design style, the rule is this: never attempt to use a particular design style for your game unless you are completely comfortable with the skills and effort needed to properly use it.

Commentary: Design Style Selection in *Fish Dish*

The artwork featured in *Fish Dish* uses a cartoon design style throughout.

There are several reasons for this. First, as a close clone of an existing game that already incorporates many cartoon-like elements, it makes sense to carry over this particular design style. Second, using a cartoon design style guarantees that the game will have a larger appeal than if it used one of the other design styles. This is due to the fact that cartoons appeal to both children and adults alike. Third, aesthetically speaking, games with cartoon-based design styles tend to work well with the Java/Netscape color palette. This means that we can create relatively attractive and colorful artwork without having to worry about accurate shading and rendering of objects. Finally, games with cartoon design styles tend to be relatively easy to design and therefore are suitable for both beginning and advanced users.

Characterization

After a suitable design style is selected, you must decide on the *characterization* of your game elements. Characterization is what gives your game characters life. In effect, it is analogous to personality. However, for our purposes, characterization refers to the stylistic and emotional interpretation of one or more game characters. It can include anything from the color of the object to the size of the object's eyes. These elements work together to instill a sense of life into a given character. Instinctively, players pick up on these elements and identify with them. For example, bad characters look mean, good characters look cute and friendly.

Unfortunately, instilling personality in your artwork is not a skill that is learned; rather it is developed through time, experience, and practice. Over time, many designers develop a specific drawing style that they are able to incorporate into the various objects they create.

Table 12-7 provides a list of common mechanisms you can use to introduce personality into game characters.

TABLE 12-7: Common Methods for Representing Characterization in Arcade Games

To make the character appear…	*Try this…*
Cute	Add large, bulbous eyes. Large eyes seem to convey a sense of wackiness in many characters. This makes characters more appealing and less threatening to many players when compared to characters that do not have large eyes.
Friendly	Add a broad smile and large eyes. People (and game players) are naturally attracted to smiling. They find it comfortable and familiar. Often, you will find what works in the real world has application for games.
Happy	Add a broad smile with wide-open eyes and raised eyebrows (if applicable to the object in question).
Mean	Add a grin and/or down-turned eyebrows that hang low over the eyes.
Old	Add white hair or wrinkles. Hair color and wrinkles imply aging in almost any context.
Sad	Add a down-turned grin.
Smart	Add glasses with large eyes. Traditionally, glasses are associated with being learned.
Stupid	Add large eyes with small pupils placed close together. Traditionally, characters with such eyes have been considered unintelligent.

Other personality traits can be added by simply studying those things around you. You would be surprised at how much video game characters tend to use real-life expressions.

It is important to realize that characterization is not just limited to expressions. The color you give certain game objects plays an important part in the player's interpretation and understanding of a game object characterization. Color could be used to enhance an object's characterization, for example, a red devil or a black knight. Chapter 7 covers this topic at length. Please refer to it when deciding on the characterization for your game.

Commentary: Characterization in *Fish Dish*

Fish Dish uses characterization extensively. All of the game's objects exhibit it through a variety of visual means. For example, to make a particular game object look stupid, it was given large eyes and a blank expression. This cues the player into the fact that that character is not considered very bright.

Similarly, color is used extensively to reinforce the characterization of *Fish Dish*'s characters. For example, the main character is a salmon and is pink. Another character is green and has a mean temperament.

Online Game Issues

Online games, compared to the average offline arcade game, require a bit more work and planning to design. Specifically, you must examine and address such issues as:

- The available display area
- Artwork file size issues
- Performance
- The color palette

The Available Display Area

Virtually all online games are played from inside a Web browser. Due to significant differences in how most browsers handle the display of content, most online games cannot count on being able to take advantage of the entire screen area that is available at a given screen resolution. For example, a browser running at a screen resolution of 800x600 does not translate into the full 800x600 resolution being available to the online game running inside of it. Often, there will be as much as 50% less screen area available to an online game at any screen resolution.

Having less usable display area available means that your game's objects, title screens, and background screens have to be smaller than if they were appearing in a comparable offline game when running at the same screen resolution. Although this places some limits on your creativity and makes designing the game artwork more of a challenge, this issue can be dealt with as long as you know how much physical area you actually have to work with.

Table 12-8 provides some estimates of the available browser display area at common screen resolutions.

TABLE 12-8: Estimated Available Browser* Display Area at Common Screen Resolutions

Screen Resolution	*Estimated Available Display Area (Minimum)*	*Estimated Available Display Area (Maximized)*
640x480	470x300	635x380
800x600	470x430	795x500
1024x768	470x600	1019x668

* Applies to 3.0 and 4.0 generation browsers only.

NOTE: For the purposes of this table, minimum represents the available display area when browsers are first started while maximized represents the available display area when the browser window is maximized.

Figure 12-6 illustrates the difference in available display area in online games compared to offline games.

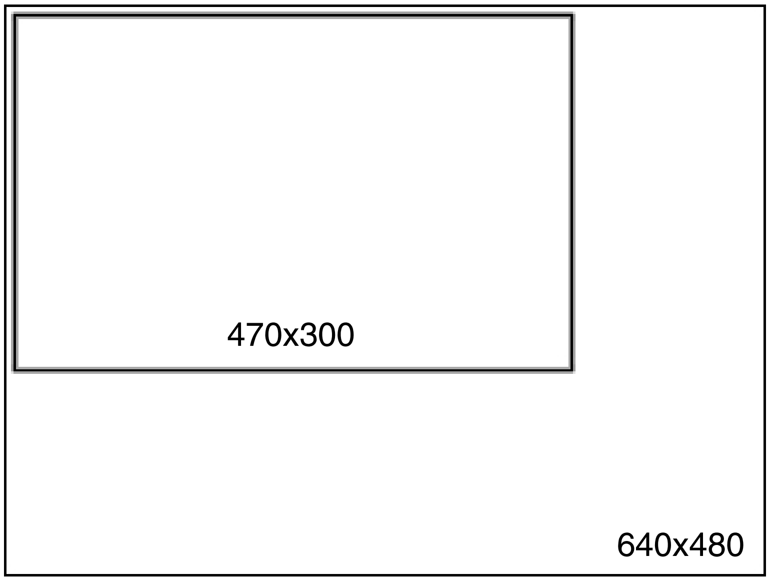


FIGURE 12-6: Comparison of Available Display Area at 640x480

In order to ensure that your online game is viewable by as many people as possible, it is strongly recommended that you always design your game's play area around the smallest available display area. According to Table 12-8, this means restricting your game screens to a maximum size of 470x300.

Commentary: Display Area Issues in *Fish Dish*

Because of the previously mentioned issue, all game screens in *Fish Dish* are restricted to a maximum size of 470x300 to ensure that they are viewable by the largest possible audience on all platforms.

Artwork File Size Issues

Despite rapid advances in communication technologies, most people do not have very fast Internet access, especially outside the United States. In fact, the vast majority of users are still connecting to the Internet with 33.6 Kbps and 56 Kbps modems. Therefore, online game developers face a nasty dilemma: they have to create games that are compelling enough to attract players, yet small enough to access and play through relatively slow Internet connections.

Unfortunately, this is not always easy to do. For one thing, arcade-style games tend to be very graphic intensive. This makes for larger, more complex programs since next to digital sound, graphic images are the most expensive component of an arcade game in terms of program size and disk space used. Second, there is the issue of the user/player's experience. With a typical online game weighing in at 200-300 KB in size, it can take most players over a minute to download and play it. The fact is that we live in an impatient world. Studies have shown that the longer a person has to wait for the computer to perform an action the more likely he is to become distracted. Therefore, it is in our best interest to do what we can to reduce the size of the game and shorten the player's wait before he can start playing.

Fortunately, we have some tricks up our sleeve. As it turns out, one of the best ways to reduce the size of online games is to use image compression since creating smaller graphic files ultimately means creating smaller games. Although there are several compressed graphic file formats available, only three are of any use for online games. These are:

- GIF
- JPEG
- PNG

Of these, GIF is the best all-around choice due to its solid compression ratios and almost universal application compatibility.

Once you have selected a compressed file format, you should try to keep every piece of game-related artwork down to reasonable file sizes. Table 12-9 provides some loose guidelines for specific limits to set for common game graphic elements.

TABLE 12-9: Online Arcade Game Artwork File Size Guidelines

Artwork Type	*Suggested Maximum File Size (in KB)*
Background Screen	< 25*
Menu Button/Element	< 1*
Single Animated Sprite	< 2.5*
Single Static Sprite	< 1.5
Status Indicator	< 8*
Title/Menu Screen	< 18*

* Actual results may vary depending on the compression scheme used and the artwork involved.

As noted, the numbers in this table will vary depending on the artwork and the image compression scheme used. This is because different compression schemes only work well on certain types of images. Table 12-10 summarizes these issues.

TABLE 12-10: Image Compression Issues and Usage Recommendations

Compression Scheme	*Issues*	*Recommendations*
LZW (GIF)	Works best on images that contain simple shapes and large areas of solid color. Images that contain large numbers of colors and complex patterns do not compress nearly as well. Especially optimized for smaller objects that cannot afford to lose any detail.	Best when used on cartoon- or retro-styled artwork.
LZ77 (PNG)	Generally similar to LZW.	Best when used on cartoon- or retro-styled artwork.
JPEG (JPEG)	Works best on images that contain complex shapes and patterns. Especially optimized for relatively large objects that can afford to lose detail.	Only use on photographic or hyper-realistically styled artwork.

Ultimately, such issues can affect the stylistic appearance of your artwork. For example, you may have to choose to design your artwork using a cartoon style instead of a realistic style in order to maximize the file compression savings offered by a particular compression scheme.

As a rule, you should limit your online game's artwork to a maximum of 25% of the game's total file size and often you will want to limit them to less. Therefore, if the game's final size is 300 KB, no more than 75 KB of it should be artwork. If it is, you will need to remove some elements or find ways to crunch down the artwork even further. Table 12-11 provides some examples of this limit applied to games at various sizes.

TABLE 12-11: Maximum Artwork Size Matrix

Final Game Size	*Maximum Artwork Size*
64 KB	16 KB
100 KB	25 KB
150 KB	37.5 KB
200 KB	50 KB
250 KB	62.5 KB
300 KB	75 KB

To determine whether your game is meeting or exceeding the maximum suggested sizes for its artwork, you need to consider several variables, including:

- MT = The maximum target size for the online game
- GC = The size of the game's code without graphics or sound
- SS = The amount of space required by the game's sound effects and/or music
- TG = The size of all the game's graphical elements

Consider this example:

```
MT = 300 KB
GC = 100 KB
SS = 100 KB
TG = 75 KB

GC (100) + SS (100) + TG (75) = 275

MT (300) – 275 = 25
```

This means that you are 25 KB under the target game size, which is great. This means that the final game will actually be smaller than originally thought and will download faster. However, in most cases, the opposite will be true and you will find that your game is actually larger than originally anticipated.

If this happens, look at your artwork file sizes and see which items can be pared down since for every 2 KB you eliminate from your game, you can save the player up to one second of download time. For larger online games, this can really add up, especially for those with really slow Internet connections.

Commentary: File Format Issues in *Fish Dish*

Fish Dish uses the GIF format to store its artwork because it provides good image compression and widespread compatibility with different programming languages, graphics tools, and computer platforms.

GIF is also a good choice for other reasons. As it happens, GIF compression works particularly well on images that contain large areas of solid color. Cartoon-style artwork usually falls into this category. Consequently, we enjoyed significant compression savings by using this file format.

Performance

Performance, or how fast and smooth a game plays, affects an online game much more than it would an offline game. The primary reason for this is due to how online games are written.

Practically all online arcade games are written using either Java or *Shockwave*. We briefly discussed Java in Chapter 1 but not *Shockwave*. For those of you not familiar with it, *Shockwave* is a compression engine for games created with *Macromedia Director*, a powerful, multimedia authoring tool. The *Shockwave* engine compresses *Director* applications so that they can be efficiently used on the Web.

Java and *Shockwave* are popular with online game developers for three reasons. First, games created with them can reach a very large audience because Java comes built into many Web browsers while the *Shockwave* player comes bundled with many computer systems. Second, they are portable across multiple platforms. With the appropriate support (a Virtual Machine in the case of Java or a special player in case of *Shockwave*) installed Java and *Director*/*Shockwave* content will run consistently regardless of the system it is running on. Finally, they provide programmers with many features that greatly speed up the development process. This means games can usually be developed much faster using these tools than with more traditional programming languages.

However, all of this flexibility comes with a price—speed. You see, both Java and *Shockwave* are highly *abstracted* development environments. This means that they execute commands through multiple layers instead of accessing the computer's hardware and operating system directly, which in turn limits performance. For example, in order for a Java game to move an on-screen object, it must send instructions to a corresponding Java function that performs this action. In turn, the Java function must then be translated into the appropriate Windows, Macintosh, or Linux operating system call and so on. In contrast, using a traditional programming language like C or C++ only requires one such translation rather than several to perform the same task. Therefore, games written using either of these technologies do not offer anywhere near the same level of performance as their offline counterparts.

To make matters even worse, games written in Java usually store their artwork as separate files. For games with many different objects, this additional overhead can further degrade performance. However, due to the way they are compressed, *Shockwave* games do not have this problem.

Table 12-12 compares the performance of Java and *Shockwave*.

TABLE 12-12: Comparison of Online Game Development Tool Performance

Online Programming Environment	*Screen Performance Rating*	*Other Issues*
Java	Mediocre to good. Depends on the game type, the complexity of the animation, and the number of objects.	Overall, performance depends on the version of Java and the implementation of the Java Virtual Machine. Game-related artwork is usually external to the game and is loaded when the game first runs, which can cause a noticeable delay.
Director/Shockwave	Mediocre to good. Depends on the game type, the complexity of the animation, and the number of objects.	Performance is tied to the speed of the player's machine and the version of the *Shockwave* player being used. Game-related artwork is usually internal to the game program and is loaded when the game first runs. The resulting performance penalty tends to be less than for Java because most, if not all, game artwork comes embedded in the game itself.

From a design perspective, there are several ways to enhance an online game's performance. These are:

- **Reducing the number of on-screen objects**—Fewer game objects means fewer items for the game to track, move, and manipulate. Limiting the number of game objects can help to speed up a game's performance.
- **Using simpler animation**—Simple animations (only a few frames) are far less resource intensive than complex animations (many frames). Using less sophisticated animations can improve game performance.
- **Reducing the size of on-screen objects**—Smaller sprites and game objects require less computing time to display, track, and move than larger sprites and game objects. Therefore, restricting the size of your game's objects can translate directly into faster overall performance.

- **Eliminating or minimizing background activity**—Background activity such as scrolling is a huge drain on a computer's resources. Removing such effects from your online game can go a long way in improving its performance.

Commentary: Performance Issues in *Fish Dish*

Fish Dish can be implemented using Java, *Shockwave*, or any other programming language for that matter. However, to ensure optimal performance regardless of the technology used, *Fish Dish* was designed with these considerations in mind:

- **Simple animation**—The need to keep game activity moving at a reasonable pace means that *Fish Dish* will use very simple animation. Specifically, *Fish Dish* uses the open/close and swing animation primitives, and several of the game's objects do not use animation at all. In addition, all game objects are limited to only a few animation frames each.
- **Static background screens**—The backgrounds used in *Fish Dish* are static in order to minimize non-essential animation and improve the game's overall performance.
- **Object size**—Most of *Fish Dish*'s game objects are small to medium in size. This was done to take advantage of the fact that smaller objects animate faster than larger ones.

These design modifications were made after a careful evaluation of *Fish Dish*'s various components so that we could maximize performance without dramatically diminishing the overall quality of the game.

Good performance is important to any arcade game, but you should never sacrifice the integrity of the game just to see a performance benefit. Rather, you should carefully weigh what is to be gained by removing or reducing the graphical elements of your game and what is to be lost. For example, although all of the design modifications to be implemented will contribute to *Fish Dish*'s performance, none of them actually detracts from the game as a whole. In other words, these changes can be made and *Fish Dish* will still be a good game. Therefore, only make design changes if they benefit the game without ruining the player's experience.

The Color Palette

All online arcade games use a common color palette known as the Java/Netscape palette. First described in Chapter 8, this palette has the ability to display artwork created with it on multiple platforms without color loss or dithering when in an 8-bit display mode. Although this property makes it very useful for online games, it has its share of issues to contend with, including:

- **Color availability**—Most color palettes give us 256 different colors to choose from and use. However, for various technical reasons, the Java/Netscape palette only gives us 216 usable colors. This leaves us with fewer available color choices and can (at times) place restrictions on our creativity.

- **Poor color variation**—As explained in Chapter 8, this palette has two major shortcomings with the colors it provides. First, there are too many saturated shades of primary colors and very few intermediate or tertiary colors. Second, there are only six shades of any one color available. This makes it useless for games that require artwork with complex shading.
- **Poor color harmony**—The colors contained in the Java/Netscape palette exhibit poor color harmony. This means that they do not work well together and give us few useful color combinations to use in our artwork.

Indeed, these issues definitely make using this palette in a game a challenge. However, one of the signs of a good designer is being able to determine how to best utilize the colors available. The key to doing this is by identifying which color combinations work well together and the most suitable styles of artwork to use with the palette in question.

It takes time and experience to really determine which colors work well with each other for a given palette. This is especially true when creating artwork for online games using the Java/Netscape palette. As it happens, there are only about 16 useful color combinations supported by this palette.

Shown in Table 12-13, these color combinations have been identified though trial by working on numerous game projects. They all provide sufficient diversity to allow you to render many different types of objects without being overly repetitious or boring. While other color combinations are indeed possible using this palette, they usually produce color combinations that are too bright, too dark, or do not provide sufficient contrast to make them effective in a game.

TABLE 12-13: Effective Color Combinations for Use in Online Games

Color Combination	*Colors (RGB Values)*
Combo 1	Dark Red: 153 0 0
	Maroon: 204 51 51
	Light Red: 255 102 102
	Pink: 255 153 153
Combo 2	Light Brown: 204 102 0
	Dark Tan: 204 153 0
	Sand: 255 204 51
	Pure White: 255 255 255
Combo 3	Dark Brown: 102 51 0
	Medium Brown: 204 102 0
	Light Tan: 255 153 0

Color Combination	*Colors (RGB Values)*
Combo 4	Magenta: 204 51 153
	Medium Pink: 255 102 204
	Hot Pink: 255 153 255
	Pure White: 255 255 255
Combo 5	Dark Gray: 51 51 51
	Medium Gray: 102 102 102
	Light Gray: 153 153 153
Combo 6	Pure White: 255 255 255
	Light Pink: 255 153 255
	Dark Purple: 102 0 153
	Light Purple: 153 102 255
Combo 7	Dark Green: 0 102 0
	Medium Green: 0 153 0
	Light Green: 102 255 0
Combo 8	Bright Green: 204 255 102
	Medium Green: 51 153 51
	Light Green: 153 255 102
Combo 9	Light Orange: 255 153 102
	Dark Red: 153 0 0
	Dark Pink: 255 102 153
Combo 10	Gold: 255 204 0
	Light Brown: 153 102 0
	Pale Brown: 204 153 102
	Flesh: 255 153 102
Combo 11	Dark Blue: 0 51 153
	Medium Blue: 0 102 255
	Light Blue: 0 153 255
	Sky Blue: 51 204 255
Combo 12	Dark Purple: 102 0 153
	Light Purple: 153 102 255
	Lavender: 204 153 255
	Pure White: 255 255 255

Color Combination	*Colors (RGB Values)*
Combo 13	Dark Green: 0 102 0
	Medium Green: 51 153 51
	Light Green: 102 204 102
	Bright Green: 153 255 153
	Very Light Green: 204 255 204
Combo 14	Dark Olive: 102 102 51
	Medium Olive: 153 153 102
	Light Olive: 204 204 153
	Very Light Olive: 255 255 204
	Pure White: 255 255 255
Combo 15	Dark Magenta: 102 51 102
	Medium Magenta: 153 102 153
	Light Magenta: 204 153 204
	Very Light Magenta: 255 204 255
	Pure White: 255 255 255
Combo 16	Dark Cyan: 51 102 102
	Medium Cyan: 102 153 153
	Cyan: 102 204 204
	Light Cyan: 153 255 255
	Very Light Cyan: 204 255 255

The lack of more than six shades for any one color and the overabundance of primary colors in the Java/Netscape palette make it largely unsuitable for creating certain types of images. Instead, it is strongly recommended to only use this palette to create retro- or cartoon-style artwork. Coming to this realization will save you time and effort later.

Usually, the palette's suitability can be determined by examining the colors at your disposal. Specifically, look for essential "indicators" or factors that can negatively affect your creativity as:

- **Available shades and tints**—As mentioned in Chapters 7 and 8, a palette with too few shades and tints per unique color prevents it from being used to effectively render realistic objects.
- **Available color types**—Many objects, particularly realistic ones, require intermediate and neutral colors. A palette with too few of these types of colors effectively rules it out for rendering realistic or complex objects.
- **Available color intensity**—A palette with an abundance of highly saturated colors makes it largely unsuitable for rendering realistic or detailed objects. Similarly, a palette with too little intensity can have the same effect.

In addition, other factors can influence a palette's suitability, including:

- **Contextual requirements**—These are the color requirements of the object(s) in question, i.e., green sky vs. blue sky, etc. You may have no choice but to use certain colors because the context of the situation demands their use. This should be one of your most important considerations, especially when trying to mimic real-world characters and objects in your game artwork. A palette is worth considering as long as it meets your contextual requirements.
- **Aesthetic requirements**—These consider issues like which colors look best against certain backgrounds and with other objects. This is essentially the color harmony of the palette. If the palette provides your game objects with sufficient coverage, then the palette is worth considering.

On the positive side, the Java/Netscape palette can produce some very attractive game artwork when used properly. This means sticking to the color combinations described in Table 12-13 and only using them to create cartoon- or retro-style artwork. Because of this, the artwork in *Fish Dish* does not use a realistic design style.

Commentary: The Color Palette in *Fish Dish*

As an online game, we really had no choice but to use the Java/Netscape palette for *Fish Dish*. However, despite the palette's obvious disadvantages, the colors in it more than meet our contextual and aesthetic color requirements. This means that it will do the trick.

Determining the Order of Element Creation

One of the challenges of designing arcade game graphics is figuring out exactly what to do first. Do you design the game's characters and animation first? Do you create the backgrounds before the title screen? As you can probably appreciate, these are important questions, especially when you consider the fact that you may be under a deadline and only have a limited amount of time to create everything for your game.

There are a number of factors to consider in determining which part of your game project to tackle first. These include such things as:

- **The quantity of objects**—For obvious reasons, the number of objects in a game can have a big effect on whether you choose to work on this part of the game's artwork first. This is simply due to the fact that more objects will take more time to design.
- **The design style**—Certain design styles require more design effort than others. For example, games with realistic artwork are more complex than those with retro artwork, and so on.

- **The type of artwork**—Some artwork is simply more difficult and time-consuming to design than others. For example, animated objects will usually take more time to create than static objects.
- **The color palette**—The color palette used can significantly affect how long it takes to create a piece of game artwork. For example, some palettes impose specific limitations on the number or types of colors you can use. This will force you to spend more time coming up with workarounds.

Given these factors and issues, it is suggested that you approach creating your game objects in this order:

1. Game sprites
2. Game backgrounds
3. Game titles and menu elements

Game sprites and any animated objects should be created first because they tend to be the most complex as well as the most numerous parts of your game. Therefore, you're bound to spend the most time creating them. The sooner you get them done and out of the way, the better off you are.

Game backgrounds can be very complex but rarely as much as sprites. Also, there tend to be fewer of them so they should not take you nearly as long to design and create.

Finally, always create your title screen and menu screen elements last. This is because they are considered game icing. That is, they are embellishments to the game and not central to it. Your game sprites and backgrounds are far more important. Far too many designers make the mistake of focusing on these elements first when they should really be creating them last.

NOTE: If you are working with other designers, some of these steps can be done at the same time. For example, you can have one artist focus on creating the title screen while another focuses on designing the backgrounds. This is typically how larger, commercial game projects are done as this arrangement maximizes resources and productivity. However, the order of element creation presented here will work for pretty much any solo game project.

Commentary: The Order of Element Creation in *Fish Dish*

Fish Dish is sufficiently complex enough that it requires the bulk of the design time to be used creating the game's various game sprites. The backgrounds are very simple, and therefore only minimal time will be allocated to them. In addition, they will be done after the main game objects have been completed. The title screen, because it is an embellishment, will also be done last.

Phase II: The *Fish Dish* Design Plan

This section of the chapter documents the various technical details associated with designing the artwork and animation for *Fish Dish*'s game objects and elements.

The *Fish Dish* Game Summary

As discussed back in Chapter 11, it is the purpose of the game summary in our design plan to help us flesh out the overall creative appearance of our game (in this case, *Fish Dish*). In addition, this is the place where we define and establish such crucial game elements as the characters that we will need to eventually design.

Game Back Story

Poor Salmon Fishdie has just hatched and is very hungry. All alone in the deep blue ocean, Salmon must rely on his speed and wits to snag a meal and grow big and fat. Unfortunately, life in the wild isn't easy because the ocean is a tough place. Salmon must constantly be vigilant and watch out for bigger, more powerful fish and even worse—sharks! Can you help Salmon fill his belly without him filling someone else's?

Game Description/Game Concept

Fish Dish is a humorous online, maze/chase version of Darwin's "survival of the fittest" theory. In it, the player controls an on-screen character in the form of a small fish named Salmon Fishdie. The player must maneuver Salmon so that he can gobble up any fish that are smaller or equal in size to Salmon while avoiding larger, predatory fish that periodically appear. The more fish that Sal eats, the larger he grows. Unfortunately, for Salmon, his predators grow as well, making it progressively more dangerous for Salmon to survive.

The goal of *Fish Dish* is very simple: the player scores points by eating other fish. When the player exhausts all of Salmon's lives, the game ends.

Game Object Inventory

As designed, *Fish Dish* includes a number of different game objects. This group of objects contains the game's *core game characters*. Core game characters are game objects central to the theme or plot of the game and usually include the player-controlled character as well as the computer-controlled enemies. In *Fish Dish*, these objects include:

- **Salmon Fishdie**—The player-controlled character. Salmon starts the game as a small, round fish with two large eyes on the same side of his face. Salmon's main ambition in life is to eat. As such, he travels the ocean looking for fish to eat that are smaller or equal to him in size while avoiding bigger and meaner fish. The more Salmon eats, the more he grows. In fact, Salmon can grow up to 7x his original size. However, even at his largest size, Salmon manages to retain the boyish good looks he had when he was a small fry. In other words, he looks more or less the same as he did at the start of the game. The player controls Salmon with the arrow keys and can move Salmon in four possible directions—up, down, left, and right. To help make Salmon easier for the player to spot in a sea of fish, he is colored pink. In addition, he is the only fish in the game that moves both his fins and mouth as he swims.

- **Salmon Fishdie Angel**—This divine, winged fish appears whenever Salmon "gives up the ghost" and becomes another fish's meal. Salmon is inherently good so he gets to go upstairs to that big ocean in the sky and swap his fins for a pair of wings.
- **Bad Tuna**—A potential predator or meal, depending on Salmon's size at the time of contact. Bad Tuna are a particularly tasty species of tuna that are known for their voracious appetites for Salmon. Bad Tuna are easily identified by their purple and lavender color scheme and large fins. Unlike other fish, Bad Tuna never swim alone.
- **Blue Angels**—A species of uncanny beauty, and like many of the fish described here, they are both a threat and meal to good ol' Salmon. Blue Angels are triangular in shape and blue in color. Despite having large eyes for their size, Blue Angels are virtually blind, making them easy prey for a hungry, ever-growing Salmon.
- **Gold Diggers**—A small species of fish known for their brownish-gold coloring and tendency to feed at the bottom of the sea. Gold Diggers are very fond of smaller Salmon but the feeling is not mutual; Salmon hates the taste of Gold Diggers. However, if hungry, Salmon considers Gold Diggers to be excellent sources of protein, vitamins, and minerals and will eat them if given the chance.
- **Gray Sharks**—A small and notoriously cowardly species of Shark. Gray Sharks are sharks only in name, as they tend to startle easily. Although they often prey on young Salmon, Salmon just as often preys on them. Despite their meek demeanor, Gray Sharks freely roam the ocean and rely on their great speed to avoid danger.
- **Green Meanies**—Another potential predator and meal of Salmon's. Plentiful and hearty, Green Meanies are one of Salmon's favorite dishes. When not being hunted, Green Meanies are one of smaller Salmon's greatest threats. Green Meanies are small, green, and round and are easy to spot no matter how many fish are in the sea. Green Meanies prefer to swim in the upper reaches of the ocean, near the surface where the water is warm.

- **Happy Clams**—A species of giant clams that are occasionally found on the ocean bottom. Although immobile, Happy Clams are impervious to attack due to their hard outer shell.
- **Head Hunter Fish**—A scourge of the sea, Head Hunter Fish are feared far and wide for their razor-sharp teeth and even nastier composure. Head Hunters love to eat Salmon, especially if he's big and fat. Head Hunter Fish are big, round, and tan in color. They can be found in all parts of the ocean and always hunt alone.
- **M.C. Hammerhead**—The oversized bully of Salmon's underwater neighborhood. M.C. Hammerhead is a giant Hammerhead Shark who knows no fear and who will eat any fish he comes across. A skilled hunter, M.C. always appears when you least expect him to. Gray in color like most sharks, M.C.'s size is equaled only by his obsession for Salmon.
- **Red Devils**—One of the smallest fish in the ocean and Salmon's easiest meal. Dark red in color, Red Devils are a small and stupid species of fish that wanders the ocean aimlessly. No one knows why or how they got such a horrible name but to Salmon they are simply known as "dinner."
- **Starfish**—Starfish are frequently found at the bottom of the ocean, alone and in pairs. When hungry, they float up to the surface in the hopes of finding food. A lazy species, they only eat what fish they run into. Unfortunately for Salmon, they would prefer to eat him over other types of fish.

In addition to these core objects, several items in *Fish Dish* can alter or enhance the abilities of the player. These objects are often referred to as *pickups*. In *Fish Dish*, the pickups include:

- **Bubbles**—Bubbles are transparent spheres that appear in various sizes and emanate from the ocean depths. Although they usually contain pockets of air, on rare occasions, some bubbles actually contain magical items that Salmon can use to his advantage in his quest to eat.
- **Pause Bubbles**—Pause Bubbles are special bubbles that contain the power to stop time for exactly three seconds. During this time, Salmon is the only fish in the ocean that can move. All other fish are stopped dead in their tracks regardless of their size or speed. Pause Bubbles make it very easy for Salmon to pig out and eat without worrying about being eaten. In some cases, they can also help get Salmon out of a tight spot. Pause Bubbles look like ordinary bubbles with miniature stoplights in them.
- **Shield Bubbles**—Shield Bubbles are special bubbles that contain the power to make Salmon invincible to bigger fish for exactly five seconds. During this time, Salmon cannot be eaten. Any fish that tries will simply bounce off Salmon, frustrated and hungry. Shield Bubbles are useful for protecting Salmon when he is small so that he can freely eat without having to worry

about becoming someone else's snack. Shield Bubbles look like normal bubbles except for a small shield icon inside of them.

Every game also has a few supporting objects that include everything from status indicators to title screens. In *Fish Dish*, these items are:

- **Title Screen**—A title screen that features a *Fish Dish* logo and a simple, game difficulty menu. The game's logo is located at the top of the screen and consists of a drawing of a fish skeleton while the game title is in thick, pink, cartoon-like lettering. The difficulty menu consists of three small buttons that resemble check boxes. The check boxes are labeled Easy, Medium, and Hard, respectively. The menu itself is positioned at the bottom of the screen.
- **Level 1 Background**—This is the background screen for all levels of the game. This screen consists of two parts: a light blue field and a dark brown field. The light blue field occupies the upper 85% of the screen and represents the ocean while the dark brown field that occupies the remaining 15% of the screen represents a seabed. The seabed itself consists of rocky and craggy mounds of earth rendered in various shades of brown.
- **Level 2 Background**—Same as in Level 1, except the game difficulty would increase.
- **Level 3 Background—**Same as in Levels 1 and 2, except the game difficulty would increase.

Game Functionality Overview

Fish Dish was originally conceived to be an online game. As such, it can be implemented using any existing programming technology and can run on virtually all platforms from Windows to the Macintosh. It is also perfectly feasible to use *Fish Dish*'s artwork for an offline game as well.

As designed, *Fish Dish* supports these features:

- Runs on any Windows 95, 98, NT, or 2000, Linux, or Macintosh computer capable of running Java or *Shockwave* (if implemented as an online-only game).
- Allows the player to oppose ten different creatures, each with a unique look and behavior.
- Allows the player to obtain temporary advantages with two pickup objects.

The Game Action Sequence

The game action sequence was also described in Chapter 11. In case you've forgotten, the purpose of this section of the design plan is to chart or "map out" the flow of action throughout *Fish Dish*. It is through this section that we gain an understanding of what game elements will be needed to be designed and how and where they will be used.

The Game Action Flowchart

Because *Fish Dish* is a simple arcade game, it has a relatively straightforward game action sequence. This sequence is shown in Figure 12-7.

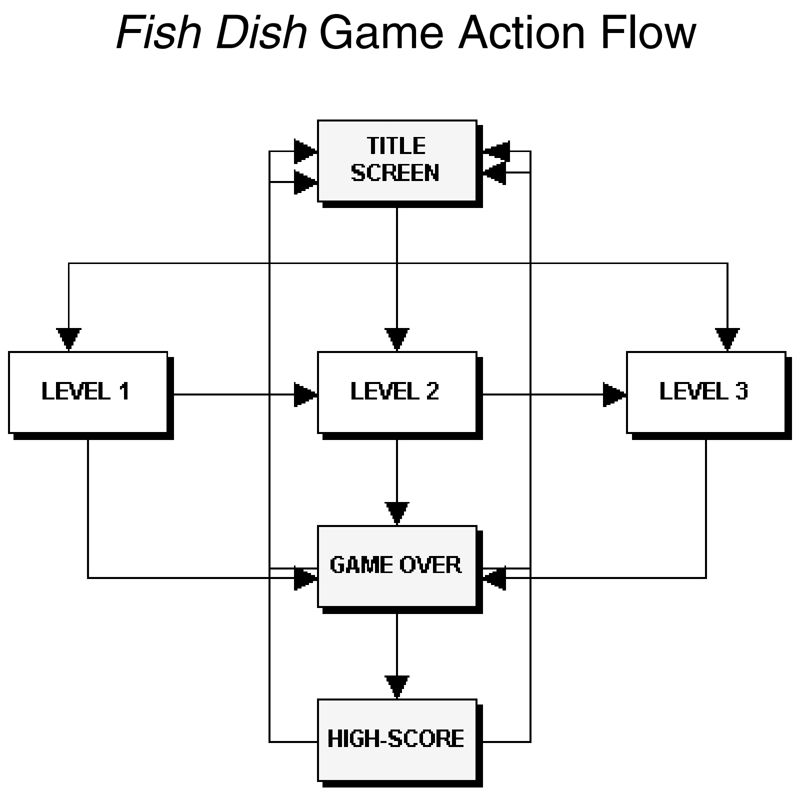


FIGURE 12-7: The *Fish Dish* Game Flow Sequence

The Screen Summary

Altogether, *Fish Dish* has five different game screens. However, only four of them are unique. The last screen, the Game Over screen, is essentially just a playing level that displays the text "Game Over" and a button that allows the player to play another game. This is a common feature of arcade-style games and is done to save space. As *Fish Dish* is an online game where space is at a premium, incorporating such efficiencies should be expected.

The direction of the arrows in Figure 12-7 indicates the flow of action between the game's various screens. The game's action breaks down as follows:

- From the title screen, the player selects a difficulty level. The choices available are Easy, Medium, or Hard.

- If the player chooses the Easy difficulty, they go to Level 1. Once Level 1 is beaten, the player progresses to Level 2. If they lose all of their available lives before completing the current level, they go to the Game Over screen.
- If the player chooses the Medium difficulty, they go to Level 2. Once Level 2 is beaten, the player progresses to Level 3. If they lose all of their available lives before completing the current level, they go to the Game Over screen.
- If the player chooses the Hard difficulty, they go to Level 3. As implemented, there is no ending or winning screen. *Fish Dish* simply continues on, filling the screen with more and more fish until it becomes virtually impossible to play. However, there is no reason why you cannot add one as an exercise.

In any case, here is a summary of the game screens in *Fish Dish*:

- Title Screen
- Level 1 (Easy difficulty)
- Level 2 (Medium difficulty)
- Level 3 (Hard difficulty)
- Game Over

Title Screen

This is the first screen that the player sees upon starting *Fish Dish*. Figure 12-8 shows what the actual title screen looks like.

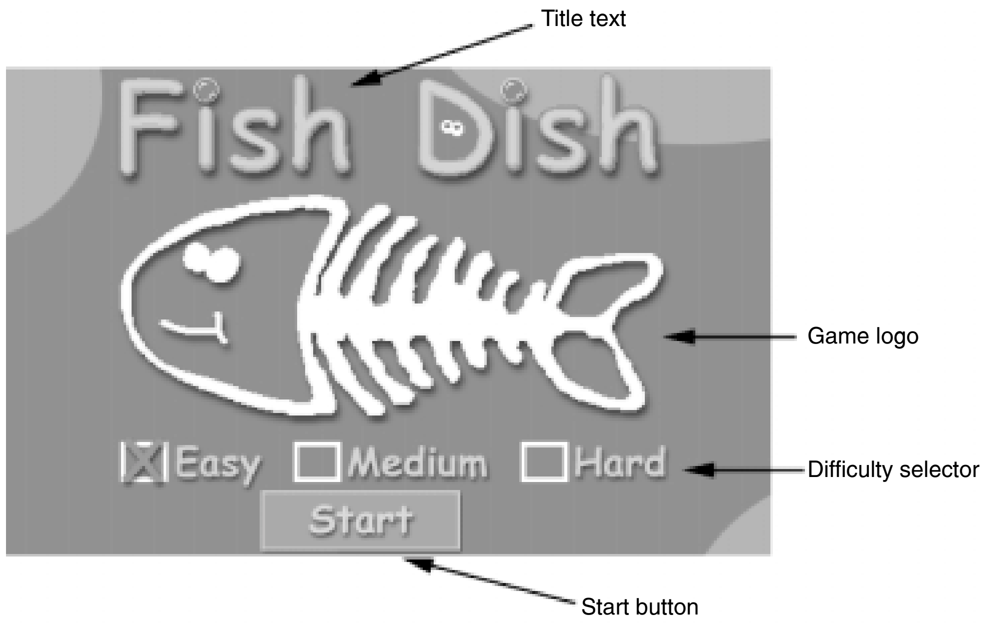


FIGURE 12-8: The *Fish Dish* Title Screen

In most games, this screen contains the program's title, logo, credits, and/or any related copyright information. It is here where the player can control the difficulty of the game as well as begin a new game. This is true regardless of whether the game is online, offline, maze/chase, or another type of arcade game.

In *Fish Dish*, the title screen contains four different elements. These are:

- The title text
- The game logo
- The difficulty selector
- The Start button

The title text is simply the game's name represented graphically. Most games, regardless of their type, use some sort of stylized title that ties back into the game's theme or plot. In *Fish Dish*, the title text is rendered using bright colors and includes elements from the game (such as bubbles and cartoon-style eyes). Not only do these elements give the title text character, but they help further reinforce their relationship to the game's plot.

The game logo is a graphical element that represents the theme or plot of the game in question. Many games feature logos that somehow tie into the game by using characters or items that are featured in the game. Other games use more abstract elements that are not in the actual game but still manage to tie into it nonetheless. *Fish Dish* falls into the latter category. The logo element consists of a cartoon-style fishbone. This was done to emphasize the general theme of the game, i.e., eating other fish and surviving. Several other concepts could have been executed in its place and would probably have the same effect, including putting a fish on a plate so that it would tie in with the game's name. Yet, to keep the example simple while effective in illustrating the point, only the fishbone motif was used here.

The difficulty selector is a menu that allows the player to determine the game's difficulty setting. The vast majority of arcade-style games usually place such menus on a separate screen; however, in order to maximize space and for the sake of illustration, it was placed on the title screen in *Fish Dish*.

As implemented, the difficulty selector consists of three check boxes in which the player merely has to click on one of them to choose a setting. Although other mechanisms could just as easily have been used, check boxes are probably the best choice. This is because they offer the player *affordances*, or subtle design characteristics that convey the correct use of an object. Therefore, people understand their purpose and know to click on them. As a rule, regardless of the type of game involved, always try to give the player as many affordances as possible.

The final item on the title screen is the Start button. This is a simple rectangle that the player clicks on to begin the actual game. Like the difficulty selector, the Start button contains such affordances as a drop shadow, a unique shape, and position on the screen so that players have no problem understanding the button's purpose within the game.

NOTE: We will examine the construction of *Fish Dish*'s title screen later in this chapter.

Level Screens (Easy, Medium, and Hard)

These are the actual game screens where all of *Fish Dish*'s activity occurs. Figure 12-9 shows an example of what a typical *Fish Dish* game level looks like.

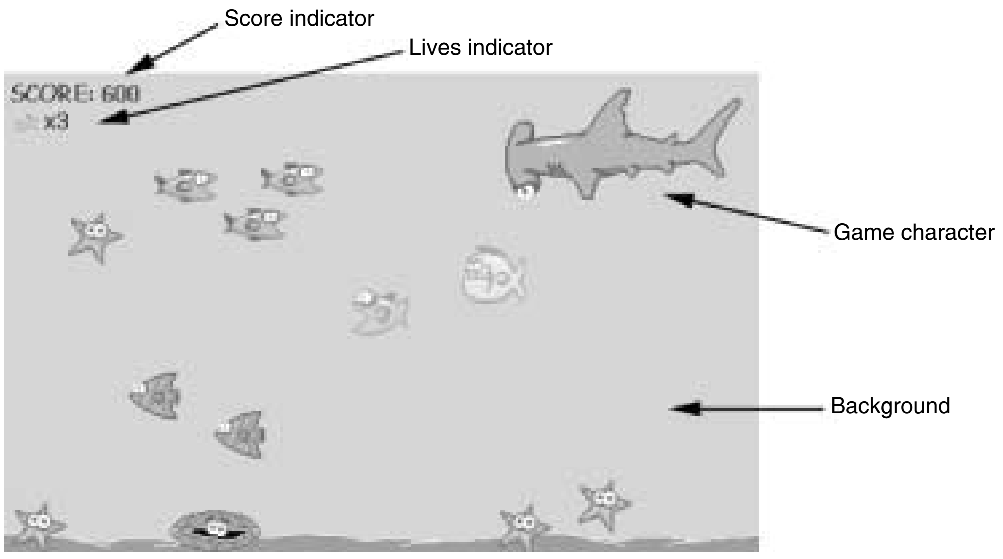


FIGURE 12-9: Example of a *Fish Dish* Game Level Screen

In most arcade games, the average level screen consists of a simple playfield along with any relevant scoring information, level information, and the current count of the player's available lives or chances.

In addition to hosting all of the game's action, each game level offers the player new game experiences. These experiences can range from introducing visual elements such as new characters or backgrounds to increasing the difficulty over the previous level.

Despite this possibility, every game level usually shares elements and objects in common. In the case of *Fish Dish*, there are four basic elements that never change, regardless of what challenges a new level brings. These items include the:

- Score indicator

- Lives indicator
- Game character
- Background

The score indicator does just what the name implies, it shows the player's current score during the course of the game. For a score indicator to be effective in its role, it must meet three essential requirements:

- It must be highly visible.
- It must be well placed on the screen.
- It must never be distracting or obtrusive to the player.

Although it might defy common sense, these three criteria are not always mutually inclusive. This is because some designers, in the attempt to make a game aesthetically pleasing, forget these requirements and sacrifice usability for the sake of appearance. This should never happen because if it does, the game may become unplayable.

A score indicator that is highly visible is, by definition, easier for the player to see. There are many ways to do this but all of these methods involve one or more of the object differentiation techniques described earlier. For example, rendering the score indicator in a large font with a light color and displaying it against a dark background can make it very easy to see when compared to using a small font and a dark color.

A score indicator should be well positioned on the game screen so that the player can easily spot it on a crowded game screen, especially during a frantic game session. Remember, for something to be seen, it must be well inside the player's field of vision. The best places for a score indicator are at the top left and bottom right of the screen. Table 12-14 provides a summary of the various places where a score indicator can appear and explains the rationale behind their placement.

TABLE 12-14: Summary of Score Indicator Positioning

Score Indicator Position	*Recommendation*	*Comments*
Top left	Highly recommended	Many players, particularly those in Europe and the United States read from left to right moving from the top down. Placing the score indicator at this part of the screen ensures that it is one of the first game elements the player sees.
Top right	Recommended	A good secondary position for the score indicator, especially when placement at the top left of the screen is impractical or impossible.

Score Indicator Position	*Recommendation*	*Comments*
Middle	Not recommended	Never place the score indicator (or any indicator for that matter) in the middle of the screen. Placing the score indicator here not only makes it difficult to see but can cause a potential conflict with the game's other objects.
Bottom left	Recommended but with reservations	An acceptable position but not preferred since this locates the score indicator outside of comfortable viewing.
Bottom right	Highly recommended	An excellent position for the score indicator because it is the last thing the player sees on the screen. This provides the player with an important visual clue as to the score's relative importance on the screen.

The third requirement of a good score indicator is to not be obtrusive or distracting to the player. In effect, this requirement directly relates to the previous two in that the score indicator's object differentiation methods and placement on the screen can become distracting if done improperly. As long as the first two requirements are addressed properly, the score indicator will never appear obtrusive to the player.

In *Fish Dish*, the score indicator meets all of these requirements. It uses a dark color that is rendered in a unique but readable font, and is positioned at the top left of the game screen. All of these factors ensure that the score remains highly visible to the player without being distracting or disruptive.

The purpose of the lives indicator is to show the player how many lives or chances they have at any point during a game. It is interesting to note that much of the same logic that applies to score indicators applies to lives indicators as well, with one significant addition: presentation. Traditionally, lives indicators in arcade-style games are iconic in nature. That is to say, they use small graphic elements, usually in the form of a smaller version of the main player-controlled character, to display the number of lives a player has left. In most cases, this device works well, as players are able to associate the icon with their on-screen character. However, in others it does not, especially when this icon runs the risk of confusing the player. For example, if a game uses a small spaceship for its lives indicator and then displays several small spaceships on the game screen, it stands to reason that some players will mistake their lives indicator for another game object. While this situation is usually not fatal, it is considered bad design. No status indicator (i.e., score indicator, lives indicator, etc.) should ever favor form over function. In other words, they should always work better than they look. One of the best ways to do this is to simply use text to represent the actual number of player lives that remain.

It was for this very reason that *Fish Dish* takes a hybrid approach. It combines an icon of a small fish (Salmon) with a numeric counter as shown in Figure 12-9. This allows the lives indicator to look good while minimizing the potential for player confusion. In addition, placing the lives indicator in *Fish Dish* close to the score indicator tells the player that it is a status device and not an active game object they can manipulate or interact with.

Game characters are the graphical objects controlled by both the player and the computer. They usually consist of animated sprites that can interact with a variety of on-screen elements. As such, they are the focal point for all of the game's action. Due to their importance, all game characters must meet three essential requirements:

- They must be easily differentiated from each other.
- Their function or purpose within a game must be visually obvious.
- They must be consistent with the game's chosen design style across all levels.

The fact that game characters should be easily differentiated from each other should go without saying. Without a means for the player to distinguish between a game's different game objects, game play would be nonexistent. Game characters should always be designed using the various differentiation devices in mind. Whether you design your characters using differences in color, size, shape, or animation does not matter as long as the differences are sufficient for the player to tell objects apart.

Fish Dish uses several differentiation devices to ensure that its game characters are uniquely identifiable to the player. This gives the game more variety and visual appeal, and reduces the potential for player confusion.

One of the greatest challenges we face as designers is to convincingly render small grids of pixels as recognizable, real-world objects. For example, does the player recognize the graphic we made as a doorway? To make matters worse, due to a variety of resolution, size, and color restrictions that various platforms impose, it can become very difficult to accurately represent certain objects. For example, does the graphic we made actually look like a door? This in turn makes it very difficult for the average player to understand the context of how an object is used within a game. For example, does the player know that they can use the door to exit the current level? So lies our dilemma. It is our job to make it as easy as possible for the player to understand what is going on in a game at all times. This extends to how objects look and work. Therefore, you should maximize your efforts to always make sure that any game objects or characters you design for a game leave some clue as to their role in the game. There are a number of ways to do this. One of the easiest and most useful techniques is to simply carry over as much of the real-world object's shape and color as possible within your particular size and color constraints. For example, if an apple is red in the real world, make sure that it is red in your game and shaped like an apple. Usually, such clues are enough to help the player make the connection as to what the object is.

Fish Dish addresses this issue by using this technique. All of its game characters are recognizable as fish so the player immediately has some understanding of what they are and how they fit into the context of the game.

It is essential that the game characters you design be consistent across the game's various screens and levels. In particular, this means the design style you chose should be reflected in all of the game's objects and not change. For example, if you design your game characters using a cartoon-like design style, make sure that all of the game's objects appear this way. The importance of consistency should not be underestimated. Simply put, players will associate the lack of consistency in your game and its characters with poor quality and bad design. Therefore, always strive to maintain whatever design convention you establish throughout your game.

Fish Dish follows this rule to a tee. Every game character that appears in it is drawn in the same design style using the same color shading techniques. This gives the game a coherent and professional look compared to a game that does not follow this requirement as closely.

Backgrounds are the actual playing area where all of the game's action occurs. Backgrounds can come in many styles and can range from the absurdly simple to the amazingly complex. Regardless of this, in order to be effective all arcade game backgrounds must follow these three rules:

- Backgrounds must provide sufficient contrast so that foreground elements stand out.
- Backgrounds must stylistically fit in with the foreground element used.
- Backgrounds must be designed with efficiency and flexibility in mind.

To be aesthetically pleasing, all game background screens must provide ample contrast. As already mentioned, contrast makes graphic elements stand out against a colored or complex background. Backgrounds that fail to provide sufficient contrast can potentially destroy the player's experience by making the game's artwork difficult to see and interact with. For example, a game with dark foreground elements should have a light background screen and vice versa. In addition, backgrounds that provide good contrast can improve the appearance and perceived quality of a game's artwork. The key to determining whether or not a given background screen has sufficient contrast can be done via the light/dark test first mentioned in Chapter 8.

Fish Dish uses a light background since most of the game's foreground elements are rendered in medium to dark colors. This produces a screen with the proper level of contrast.

Not only must a background screen have the proper contrast, but it must also be stylistically consistent with the various foreground game objects used. This means, for example, that if a game uses retro-style foreground elements, so should its backgrounds. Game backgrounds that do not stylistically fit in with a game's established look and feel will seem poorly executed to the average player. Many inexperienced designers make this mistake and, for example, use photo-realistic backgrounds with cartoon-style foreground objects. Do not make this mistake.

Figures 12-10 and 12-11 illustrate this important concept. In Figure 12-10, item A is rendered in a realistic design style while item B is rendered in a cartoon design style. It should be obvious that the two objects are stylistically incompatible with each other and should not be used in the same game. Meanwhile, in Figure 12-11, both items A and B are rendered using a realistic design style. This makes them stylistically compatible with each other and therefore they can and should be used together in a game. Incidentally, this logic applies to both background and foreground objects.

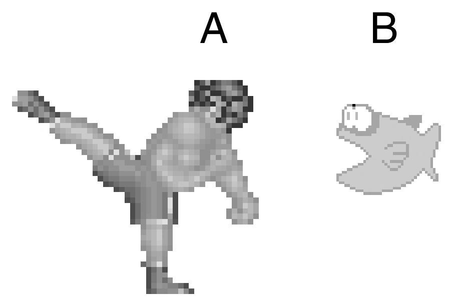


FIGURE 12-10: Incorrect Style Example

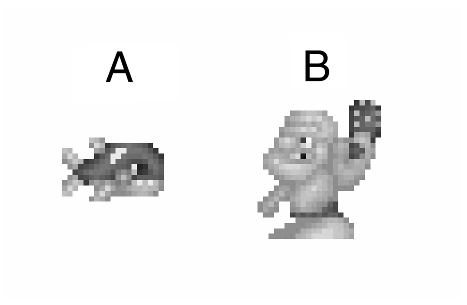


FIGURE 12-11: Correct Style Example

As expected, the backgrounds in *Fish Dish* closely match the style established by its game characters. This creates a unique synergy between the game's various elements to which the player can relate, which in turn helps them perceive *Fish Dish* as a high-quality production.

Although it is often overlooked by many designers, it is extremely important that your game backgrounds be designed with efficiency and flexibility in mind. This means that backgrounds should be designed to optimize well when compressed. Such efficiencies can be achieved by using large areas of solid colors, reducing the number and arrangement of complex patterns, and using several pieces to represent a background rather than a single image. As you can imagine, practicing background screen efficiency can greatly reduce the file size of a game, especially if it is to be distributed or played online.

Flexible backgrounds make it possible to expand the type, number, and variety of levels in a game. Often, you can create more variations by breaking a background screen into smaller pieces and then arranging them in mosaic tile fashion. For example, by drawing parts of trees such as leaves, branches, and trunks one could create an entire forest in less space and with more variations then if each forest image was created individually. Incidentally, this technique has been used for years to good effect in video game systems.

The backgrounds in *Fish Dish* are designed with such efficiency and flexibility in mind. For one thing, they consist of large areas of solid colors. This makes them compress very well. Furthermore, the backgrounds are flexible because they include a number of elements that can be reused to construct additional background screens as needed.

NOTE: We are skipping the screen mockups that would ordinarily have been part of our design plan because they were presented as part of this section of the chapter.

Game Over Screen

The Game Over screen appears at the end of an arcade game, usually when the player exhausts all of their lives or chances. Figure 12-12 shows an example of what the Game Over screen in *Fish Dish* might look like:

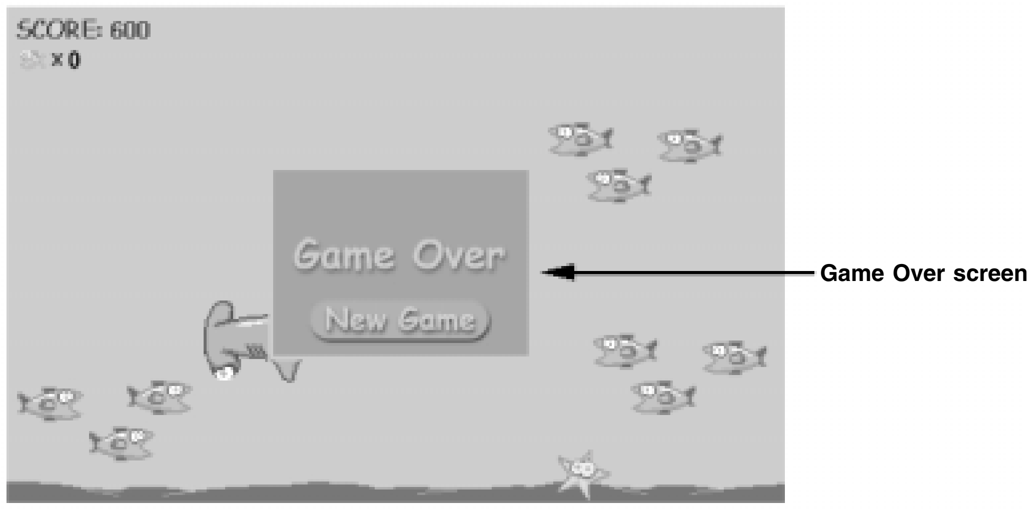


FIGURE 12-12: The *Fish Dish* Game Over Screen

Some arcade games make the Game Over screen into a fancy affair and include additional artwork or animation that ties into the game's plot in order to tell the player that they lost.

The vast majority of arcade games do not need to go this far. In fact, one can get away with a Game Over screen that just displays a message that says "Game Over." However, in order to be truly effective, any Game Over screen should really meet two requirements:

- The Game Over message should be obvious and visible.
- The Game Over screen should provide a means of letting the player start a new game.

Nothing is more confusing and frustrating for a player than to not know when a game is actually over. Sure, we might assume that the lives indicator would cue them to this fact, but as designers, we cannot always make such assumptions. Therefore, we must always let the player know that the game is over. Knock them over the head with the message so that there can be no doubt in the player's mind. This can be done in several ways, such as using large text, certain color combinations, animation, certain placements, or even sound. As long as you catch their attention with the game's Game Over message, there will be no doubt in the player's mind that the game is indeed over.

Players hate it when a game ends and they have no obvious mechanism for starting a new game. Why not make it easy for them and provide a way for them to immediately play again? The easiest and most obvious way to do this is to simply include a Play Again or New Game button on your game's Game Over screen. This will save the player frustration and encourage them to keep playing your game.

Fish Dish meets both of these requirements. First, it includes a *Game Over dialog*. This is simply a graphical box that displays a "Game Over" message positioned at the center of the screen so there can be no doubt in the player's mind that the game has actually ended. In addition, it includes a large button that is labeled "New Game" so the player has an easy method for playing again.

The *Fish Dish* Graphics Specification

The next several pages contain the graphics specification for *Fish Dish*.

Game Creative Statement

Creatively speaking, *Fish Dish* artwork is drawn using a cartoon design style. In addition, bright colors were used to further highlight the light-hearted and comedic nature of the game.

Artwork Orientation

The artwork in *Fish Dish* is rendered using a *profile* orientation, i.e., the objects appear as if viewed from the side.

Arcade game graphics can be oriented in one of three ways: from the side (profile), from above (top-view), or in simulated 3D space (isometric). Figure 12-13 illustrates these orientations.

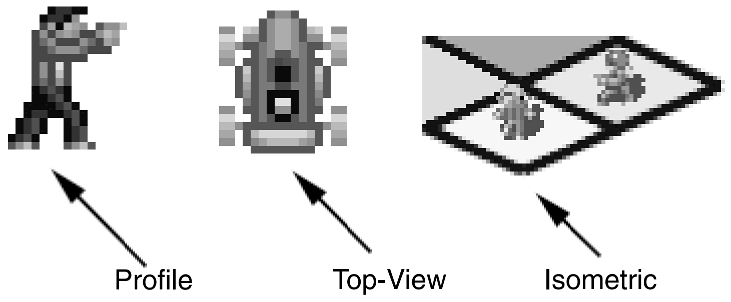


FIGURE 12-13: Object Orientation Examples

An arcade game should only use the profile or top-view orientations for their artwork. Although they can produce some very striking visual effects, isometric orientations tend to work best for non-arcade type games such as RPG (role-playing games) and simulations.

In addition, you should only use one orientation for your artwork at any one time, as no orientation scheme is complementary with another. For example, it would look very strange for an arcade shooter that uses a profile orientation to suddenly introduce objects that use a top-view orientation and vice versa. Therefore, determine which orientation to use and stick to it for the duration of the project.

Target Platform

As mentioned in several places in this chapter, *Fish Dish* is designed as an online game capable of running on virtually any 32-bit Windows, Linux, or Macintosh machine with the appropriate language support (i.e., Java or *Shockwave*). However, it is not limited to this and can be easily adapted to an offline format with minimal changes.

Estimated Object Count

In all, there are about 27 different objects in *Fish Dish*, including all variations of Salmon Fishdie and the various supporting elements (i.e., title and background screens).

NOTE: The graphics for *Fish Dish* were designed to be extensible enough to allow virtually anyone to extend the basic graphics set to include additional objects not described in the game object inventory.

Artwork Screen Resolution and Playfield Size

All of *Fish Dish*'s graphics were designed in a 640x480 screen resolution. Because the artwork was conceived with online play in mind, the active game area of *Fish Dish* was implemented using dimensions of 470 pixels wide by 300 pixels high. See our discussion of online game considerations earlier in this chapter.

Artwork Color Depth

All of *Fish Dish*'s graphics were designed for use in an 8-bit (256-color) display mode. This allows them to be used on a variety of different systems whether they support high color display modes or not. It also enables *Fish Dish* to take advantage of color cycling and other effects that palette-based display modes support should they be implemented by the game's programmer(s).

Refer to Chapter 2 for more information on the subject of color depth and Chapter 8 for more information on the topic of palettes and color cycling.

Artwork File Format(s)

All of *Fish Dish*'s artwork is stored using GIF 89a files. This makes its graphics assets compatible with the widest range of graphics programs and development tools, especially if its artwork is incorporated into an online game.

Artwork File Naming Scheme

The graphic assets in *Fish Dish* use a file naming scheme that is very similar to the example described in Chapter 4 of this book. Be aware that all of the game's assets were named so that they would be compatible with both Windows and Macintosh systems (i.e., maximum of 31 characters with file extensions).

Here is a breakdown of the suggested file naming scheme for *Fish Dish*:

NOTE: The object dimensions used for these filenames are for demonstration purposes only.

Backgrounds:

- bkg-level1-470x300.gif—Background screen for level 1
- bkg-level2-470x300.gif—Background screen for level 2
- bkg-level3-470x300.gif—Background screen for level 3

Title Screen:

- img-titlescreen-470x300.gif—Completed title screen

Sprites:

- spr-sal-470x300.gif—Sprite animations for Salmon
- spr-badfish-470x300.gif—Sprite animations for the other fish

Supporting and Miscellaneous Elements:

- mnu-easybutton_unsel-131x38.gif—The unchecked button for the easy difficulty setting
- mnu-easybutton_sel-131x38.gif—The checked button for the easy difficulty setting
- mnu-medbutton_unsel-131x38.gif—The unchecked button for the medium difficulty setting
- mnu-medbutton_sel-131x38.gif—The checked button for the medium difficulty setting
- mnu-hardbutton_unsel-131x38.gif—The unchecked button for the hard difficulty setting
- mnu-hardbutton_sel-131x38.gif—The checked button for the hard difficulty setting
- mnu-startbutton-123x38.gif—The game Start button
- img-fishdish_title-346x72.gif—The game title text
- img-fishfish_logo-346x148.gif—The game logo
- img-title-back-470x300.gif—The title screen background pattern
- img-gameover-160x118.gif—The Game Over dialog box

Artwork Color Palette

The *Fish Dish* color palette uses the Java/Netscape system palette. This color palette was then modified to include the 20 Windows reserved colors described in Chapter 8. Doing this allows the artwork in *Fish Dish* to be used as both an online and offline arcade game.

The palette is supplied in the Microsoft .PAL format. The file is called `fishdish.pal`.

The transparent color for this palette is index (palette entry) 0 which is also RGB: 0,0,0 or black.

The actual RGB values for the color palette can be found on the book's accompanying CD-ROM. Please see Appendix B for additional details.

Artwork Gamma Level

Fish Dish uses a 2.2 gamma level since its artwork was designed on a Windows system. However, because the Java/Netscape color palette contains color definitions that are the same across Windows and the Macintosh, gamma-related issues do not have a significant impact.

Artwork Object Dimensions

Fish Dish uses several different grid sizes to contain its various objects and elements. All of the main game characters use sprite grids that range in size from 16x16 to 40x40. This was done to support the "growing" effect of the game's main character. In addition, several of the larger objects use sprite grids up to 148x72 pixels in size.

These sizes were selected because they maximize the amount of object detail that can be displayed while remaining relatively efficient in terms of their screen performance and file size.

In any case, here is a breakdown of the sprite grid sizes of the different objects in *Fish Dish*:

Salmon Fishdie:

- 16x16, 20x20, 24x24, 28x28, 32x32, 36x36, 40x40

Salmon Angel:

- 16x16

Bad Tuna:

- 36x36

Blue Angels:

- 32x32

Gold Diggers:

- 20x20

Gray Sharks:

- 28x28

Green Meanies:

- 24x24

Happy Clams:

- 66x30

Head Hunter Fish:

- 40x40

M.C. Hammerhead:

- 148x72

Red Devils:

- 16x16

Starfish:

- 36x36

Bubbles and Pickups (All):

- 24x24

Frames per Object

Due to its simplicity, most of *Fish Dish*'s objects are animated using minor animation techniques like the swing and open/close primitives. This results in animations that use a relatively small number of total frames.

Here is a breakdown of the different game objects:

NOTE: Only objects that require animation are included in this list.

- **Salmon Fishdie:** Moving—5 frames (x7) sizes = 35 frames total
- **Salmon Angel:** Flying—3 frames (x1) size = 3 frames total
- **Bad Tuna:** Moving—5 frames (x1) size = 5 frames total
- **Blue Angels:** Moving—5 frames (x1) size = 2 frames total
- **Gold Diggers:** Moving—5 frames (x1) size = 2 frames total
- **Gray Sharks:** Moving—5 frames (x1) size = 2 frames total
- **Green Meanies:** Moving—5 frames (x1) size = 2 frames total
- **Happy Clams:** Moving—1 frame (x1) size = 1 frames total
- **Head Hunter Fish:** Moving—5 frames (x1) size = 5 frames total
- **M.C. Hammerhead:** Moving—1 frame (x1) size = 1 frame total
- **Red Devils:** Moving—1 frame (x1) size = 1 frame total

- **Starfish:** Moving—1 frame (x1) size = 1 frame total

Object Actions and Facings

This section lists the actions and directional facings for the key game objects.

NOTE: Only objects that require animation are included in this list.

- **Salmon Fishdie:** Moving—2 directions (left and right)
- **Salmon Angel:** Flying—1 direction (up)
- **Bad Tuna:** Moving—2 directions (left and right)
- **Blue Angels:** Moving—2 directions (left and right)
- **Gold Diggers:** Moving—2 directions (left and right)
- **Gray Sharks:** Moving—2 directions (left and right)
- **Green Meanies:** Moving—2 directions (left and right)
- **Happy Clams:** Moving—2 directions (left and right)
- **Head Hunter Fish:** Moving—2 directions (left and right)
- **M.C. Hammerhead:** Moving—2 directions (left and right)
- **Red Devils:** Moving—2 directions (left and right)
- **Starfish:** Moving—2 directions (left and right)

Game Text Font(s)

Fish Dish does not display a significant amount of textual information on its screens. However, it does use one font:

- **MS Comic Sans**—This font appears throughout *Fish Dish*. It is used extensively on the title screen where it appears in the game title text, difficulty selector, and Start button. It is also used in both the score and lives indicators. Finally, it appears in the Game Over dialog. This font was chosen because it has a distinctive appearance that is reminiscent of the type that is used in cartoons and comics. It was thought that this characteristic would blend in perfectly with the rest of *Fish Dish* given its humorous plot and engaging cartoon-like elements.

Phase III: The *Fish Dish* Design Execution

This part of the chapter focuses on how the various objects in *Fish Dish* were designed and created.

Artwork Templates

The fastest and most efficient way to create artwork for an arcade game is to *templatize*, or systematically develop a process for constructing each game element. Doing this allows you to break your artwork into a series of simple and consistently repeatable steps, which reduces the possibility for making mistakes while helping you maintain a good level of control over image quality.

Although not every game project lends itself to such a system, most do. In *Fish Dish*, two sets of templates were used, a design template which guided the creation of the game artwork and an animation template which guided the development of the related object animation.

Table 12-15 shows the basic components of the *Fish Dish* design template.

TABLE 12-15: The General *Fish Dish* Design Template

Step #	*Procedure*	*Description and Purpose*
1	Create the general object shape	The basic shape of the object is created, usually from a paper sketch or a simple pixel-by-pixel drawing.
2	Establish object coloring	The object begins to be filled in with a base color and the basic boundaries of the different parts of the object begin to become visible.
3	Add expressive and other functional elements	This is where the various expressive elements such as the eyes, eyebrows, and teeth are created as well as where functional design elements such as the fins are added.
4	Shade and complete	The object is completely colored and shaded and the final detailing is added.

Using this scheme, the average game object in *Fish Dish* can be completed in just four steps. A few objects even require just three.

Once the game object is completed, it must be animated. To simplify this process, we have devised an animation template for use in *Fish Dish*. Table 12-16 shows the basic components of the *Fish Dish* animation template.

TABLE 12-16: The General *Fish Dish* Animation Template

Step #	*Procedure*	*Description and Purpose*
1	Draw starting movement	The starting key-frame of the animation (usually a swing or open/close primitive) is created.
2	Draw the ending movement	The ending key-frame of the animation (usually a swing or open/close primitive) is created. All animated objects in *Fish Dish* use two to three frames of animation and no in-betweens in order to keep the animation sequences very simple.

Step #	*Procedure*	*Description and Purpose*
3	Test the animation	Once the animation sequence is completed, it is tested. If it looks good, we go on to step 4, otherwise, we revisit steps 1 and 2 until we get it right.
4	Horizontally flip the object frames	Where applicable, completed animations are flipped horizontally so we can have objects that appear to move from both left to right and right to left. Doing this is a real time saver as it allows us to only draw one set of images for both directions.

Step-by-Step Game Object Design

At this point, we are now ready to examine the design and construction of each game object in detail.

From here on in, each game object will be visually broken down into its basic components to better illustrate how the final object was designed and created. For the purposes of clarity, every character is provided with detailed figures that show the progression of the object's design and that maps directly to a unique step in the design template. There is not a one-to-one mapping of the animation sequences to the animation template shown in Table 12-16. Instead, the exact frame-by-frame sequence is provided. However, you are encouraged to follow the process established in Table 12-16.

Because this book is printed in black and white as opposed to color, a special visual color map diagram is also provided so that you can see where the colors for a given object are supposed to be applied.

NOTE: The master files for all of *Fish Dish*'s artwork can be found on the book's CD-ROM in the `EXAMPLES/FISHDISH` directory.

Before proceeding, you should familiarize yourself with the basic visual elements of the characters in *Fish Dish* as most of the game's objects and characters share one or more of these elements in common. They are identified in Figure 12-14.

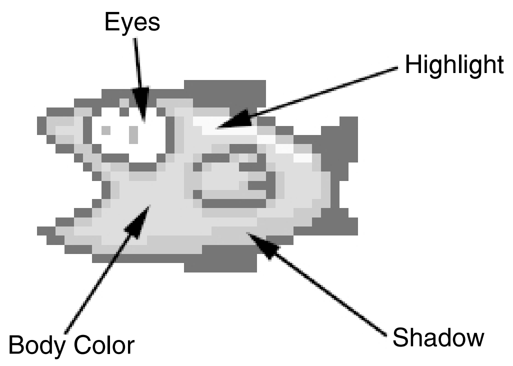


FIGURE 12-14: General Object Element Map

Salmon Fishdie Object Creation

TABLE 12-17: The Salmon Fishdie Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Magenta	62	204 51 153	The primary object bounding and detailing color
Medium pink	19	255 102 104	The shadow color
Hot pink	12	255 153 155	The main body color
Light gray	43	204 204 204	The eyeball shading color
Pure white	255	255 255 255	The eyeball and body highlighting color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

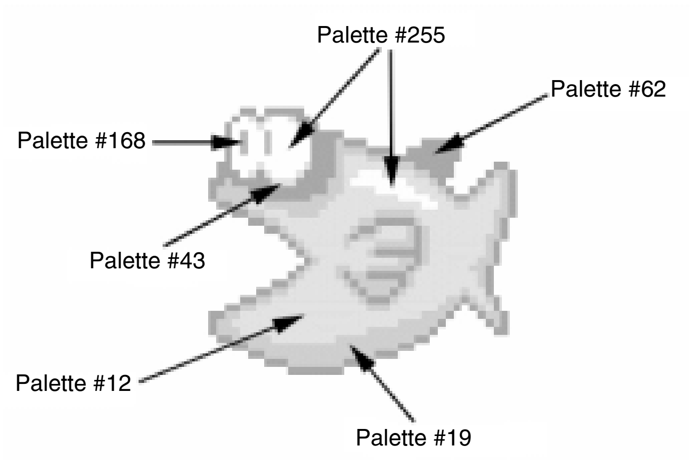


FIGURE 12-15: The Salmon Fishdie Visual Color Map

The Salmon Fishdie Design Templates

Figures 12-16 through 12-22 illustrate the progressive development of the various Salmon Fishdie objects.

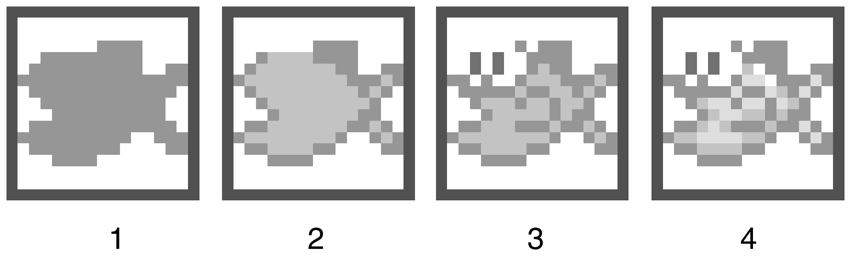


FIGURE 12-16: The 16x16 Salmon Fishdie Design Template

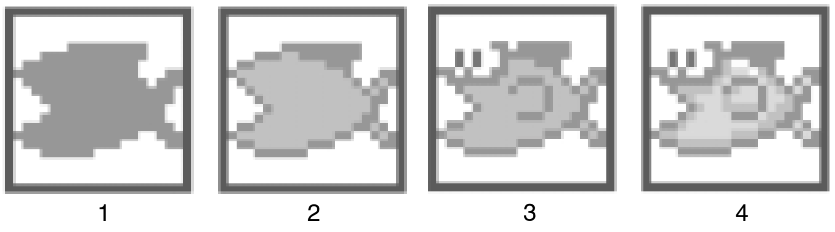


FIGURE 12-17: The 20x20 Salmon Fishdie Design Template

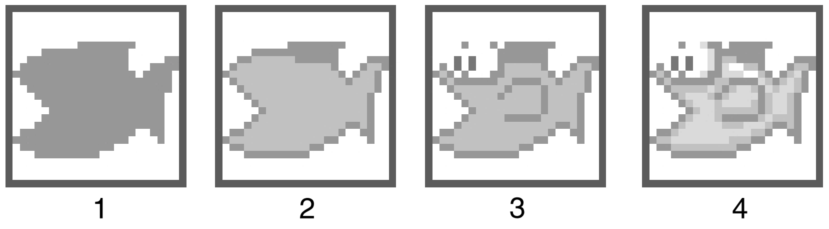


FIGURE 12-18: The 24x24 Salmon Fishdie Design Template

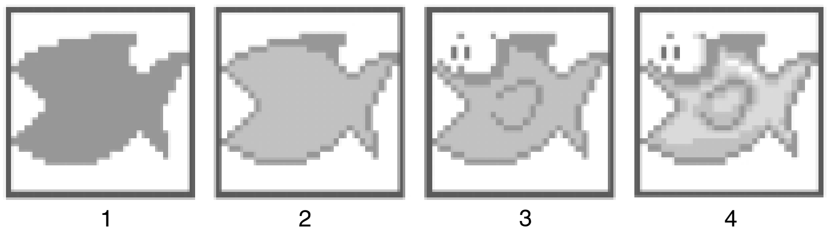


FIGURE 12-19: The 28x28 Salmon Fishdie Design Template

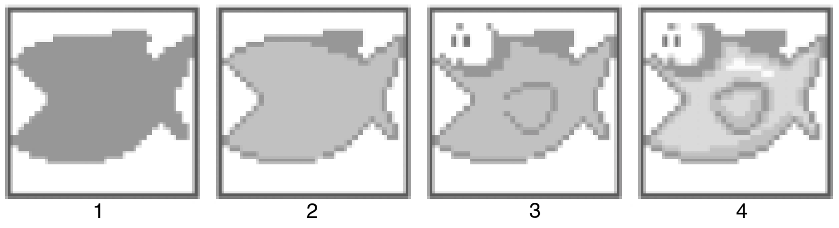


FIGURE 12-20: The 32x32 Salmon Fishdie Design Template

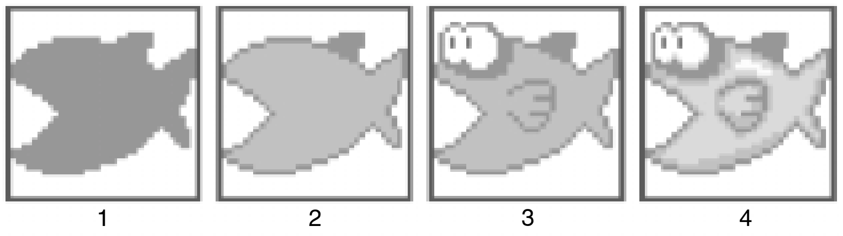


FIGURE 12-21: The 36x36 Salmon Fishdie Design Template

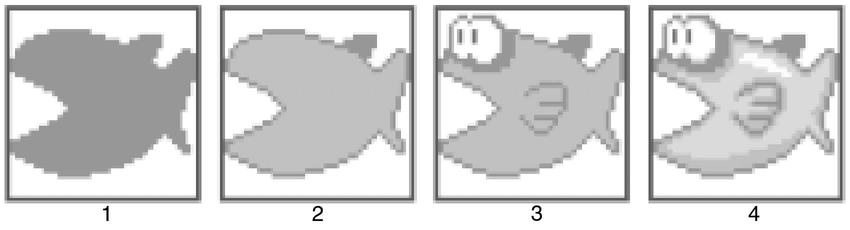


FIGURE 12-22: The 40x40 Salmon Fishdie Design Template

The Salmon Fishdie Animation Templates

Figures 12-23 through 12-29 show the animation sequences of the various Salmon Fishdie objects. There are five frames in each sequence and each sequence uses cycling and loops. These animations are also excellent examples of the open/close primitives described in Chapter 9.

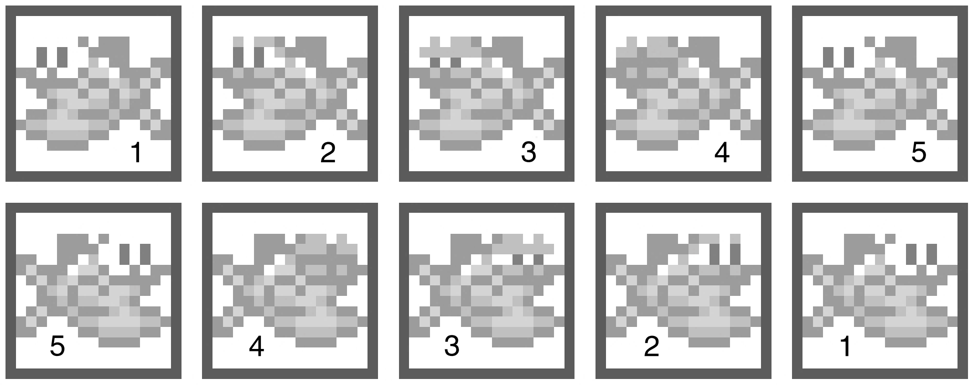


FIGURE 12-23: The 16x16 Salmon Fishdie Animation Template

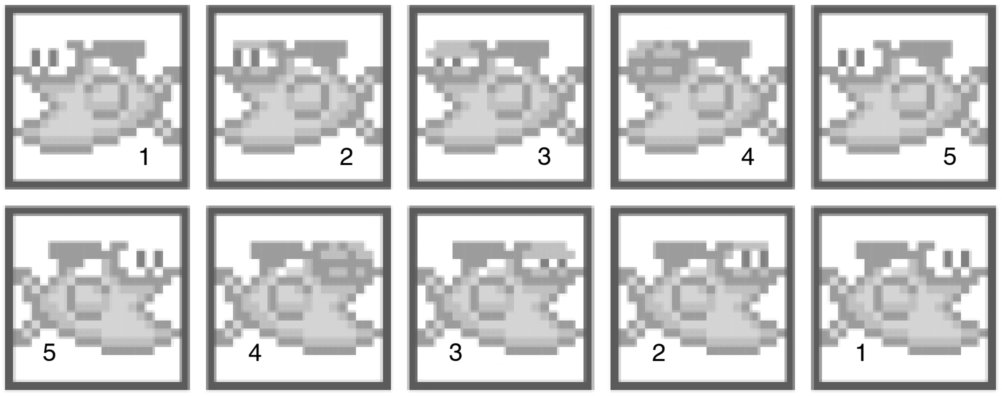


FIGURE 12-24: The 20x20 Salmon Fishdie Animation Template

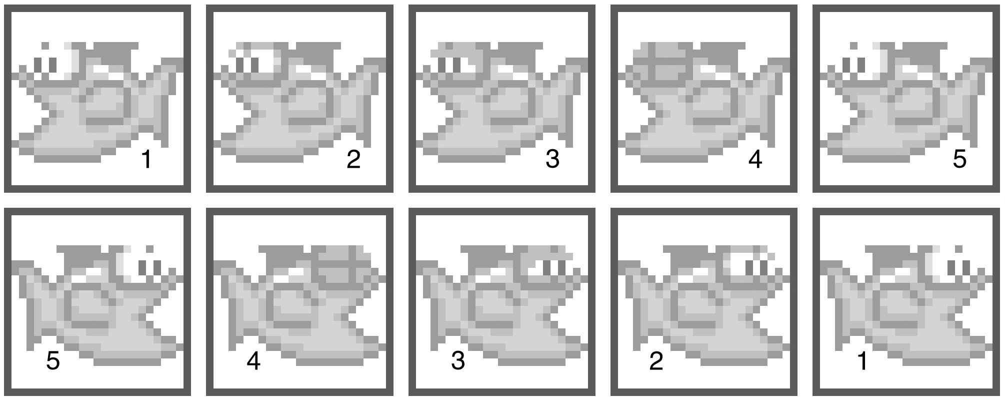


FIGURE 12-25: The 24x24 Salmon Fishdie Animation Template

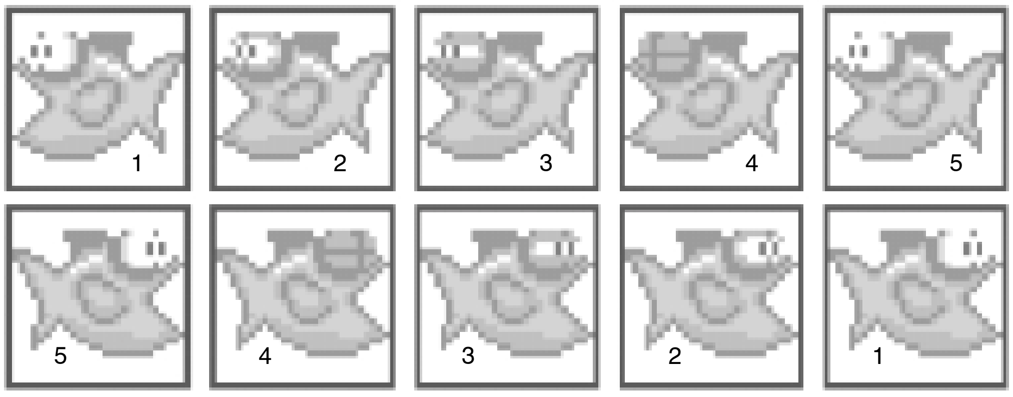


FIGURE 12-26: The 28x28 Salmon Fishdie Animation Template

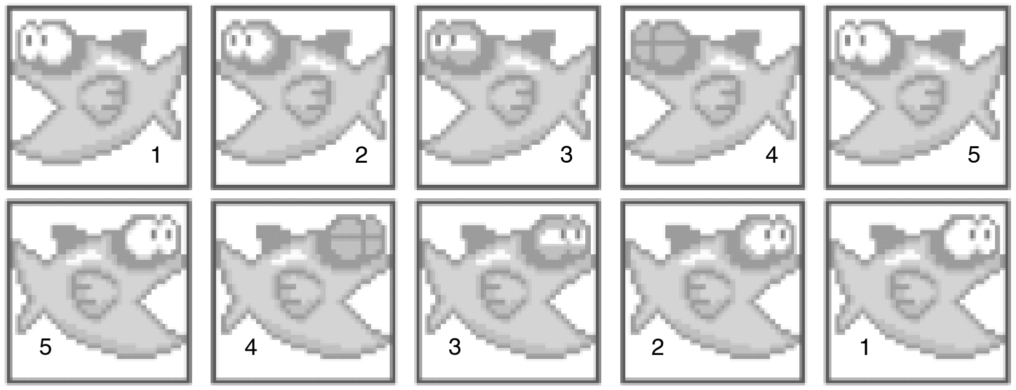


FIGURE 12-27: The 32x32 Salmon Fishdie Animation Template

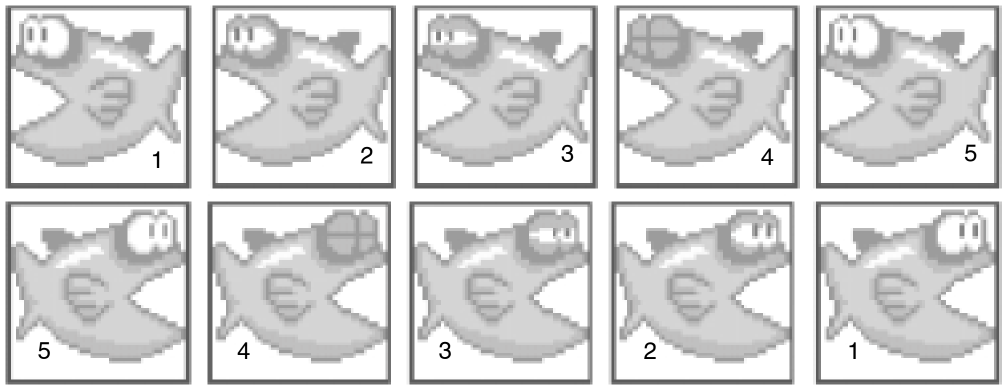


FIGURE 12-28: The 36x36 Salmon Fishdie Animation Template

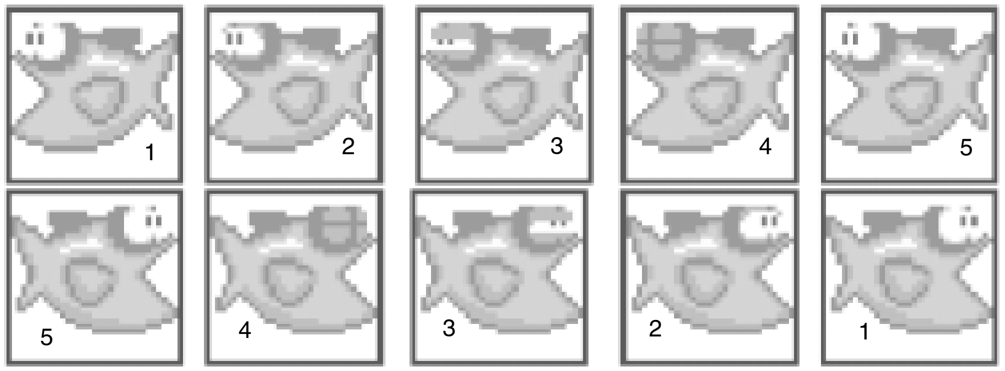


FIGURE 12-29: The 40x40 Salmon Fishdie Animation Template

Red Devil Object Creation

TABLE 13-18: The Red Devil Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Medium red	107	153 0 0	The primary object bounding and detailing color
Light red	64	204 51 51	The main body color
Pure white	255	255 255 255	The eyeball color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

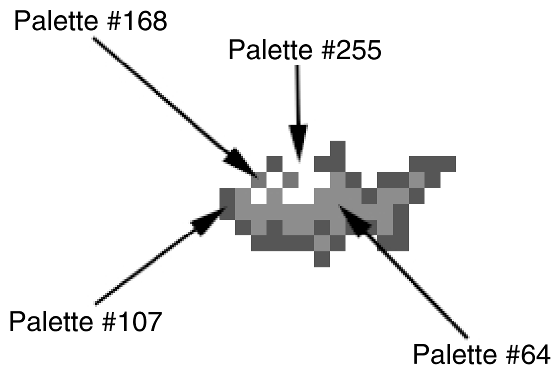


FIGURE 12-30: The Red Devil Visual Color Map

The Red Devil Design Template

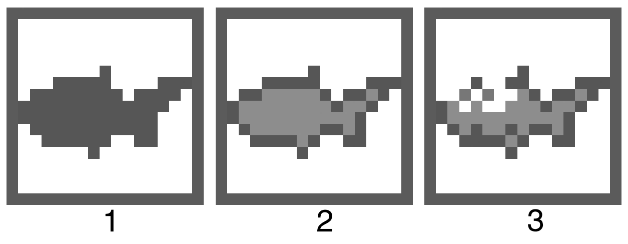


FIGURE 12-31: The Red Devil Design Template

Gold Digger Object Creation

TABLE 12-19: The Gold Digger Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark brown	137	102 51 0	The primary object bounding and detailing color
Medium brown	95	153 102 0	The shadow color
Light brown	53	204 153 0	The secondary shading and detailing color
Very light brown	10	255 153	The main body color
Pure white	255	255 255 255	The eyeball and body highlighting color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

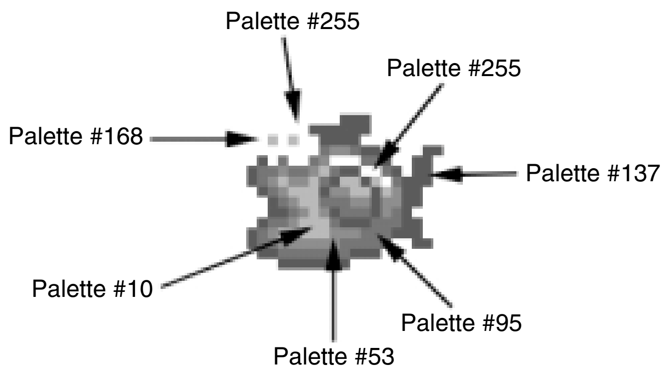


FIGURE 12-32: The Gold Digger Visual Color Map

The Gold Digger Design Template

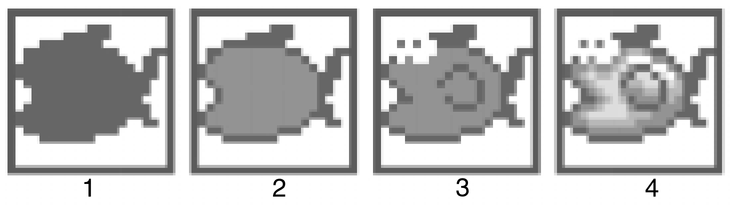


FIGURE 12-33: The Gold Digger Design Template

The Gold Digger Animation Template

Figure 12-34 contains the complete animation sequences for the Gold Digger character. Notice that this animation consists of five frames, makes use of cycling and loops, and uses the open/close animation primitive.

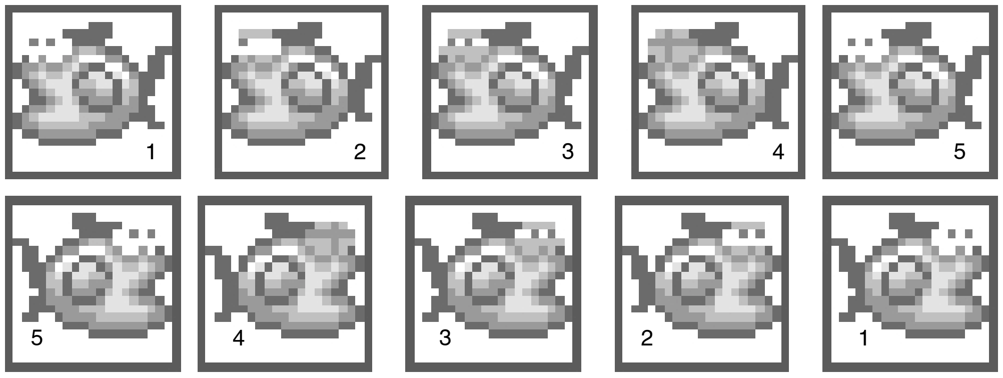


FIGURE 12-34: The Gold Digger Animation Template

Green Meanie Object Creation

TABLE 12-20: The Green Meanie Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark green	203	0 102 0	The primary object bounding and detailing color
Medium green	197	0 153 0	The shadow color
Light green	191	0 204 0	The main body color
Very light green	113	102 255 0	The body highlighting color
Pure white	255	255 255 255	The eyeball color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

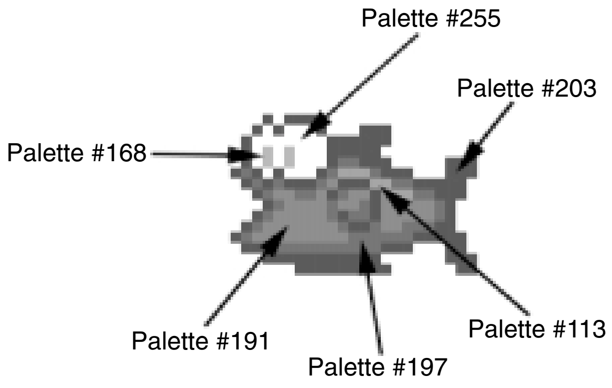


FIGURE 12-35: The Green Meanie Visual Color Map

The Green Meanie Design Template

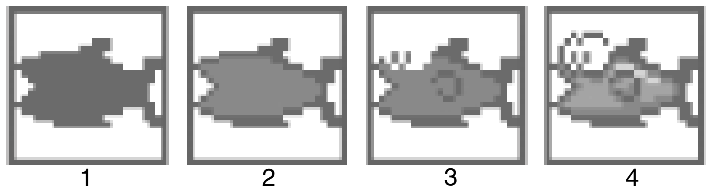


FIGURE 12-36: The Green Meanie Design Template

The Green Meanie Animation Template

Figure 12-37 contains the complete animation sequences for the Green Meanie character. Notice that this animation consists of five frames, makes use of cycling and loops, and uses the open/close animation primitive.

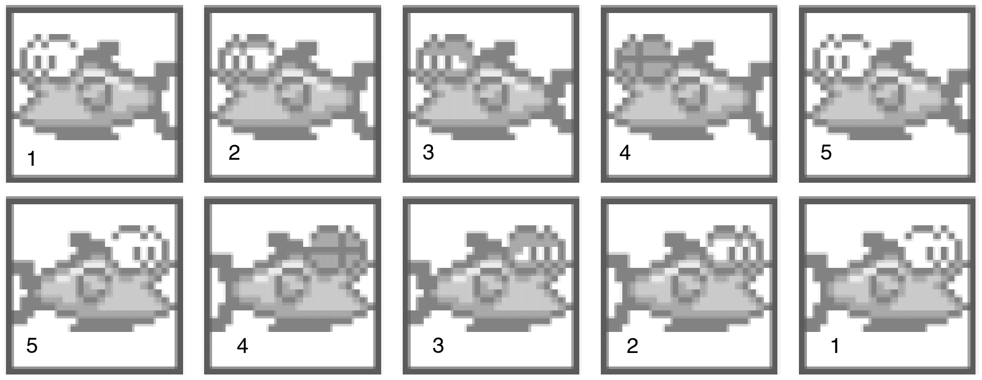


FIGURE 12-37: The Green Meanie Animation Template

Gray Shark Object Creation

TABLE 12-21: The Gray Shark Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark gray	172	51 51 51	The primary object bounding and detailing color
Medium gray	129	102 102 102	The shadow color
Light gray	86	153 153 153	The main body color
Very light gray	43	204 204 204	The highlighting color
Pure white	255	255 255 255	The eyeball color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

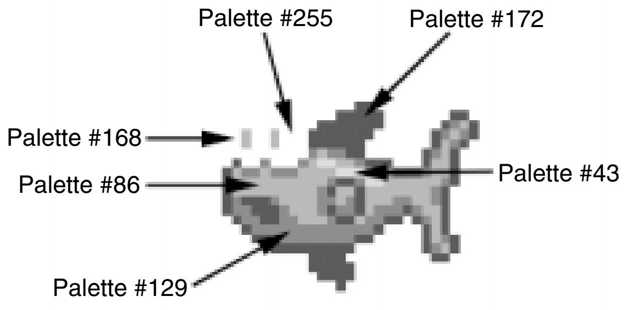


FIGURE 12-38: The Gray Shark Visual Color Map

The Gray Shark Design Template

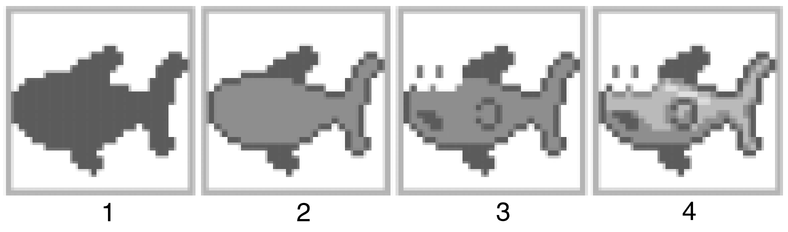


FIGURE 12-39: The Gray Shark Design Template

The Gray Shark Animation Template

Figure 12-40 contains the complete animation sequences for the Gray Shark character. Notice that this animation consists of five frames, makes use of cycling and loops, and uses the open/close animation primitive.

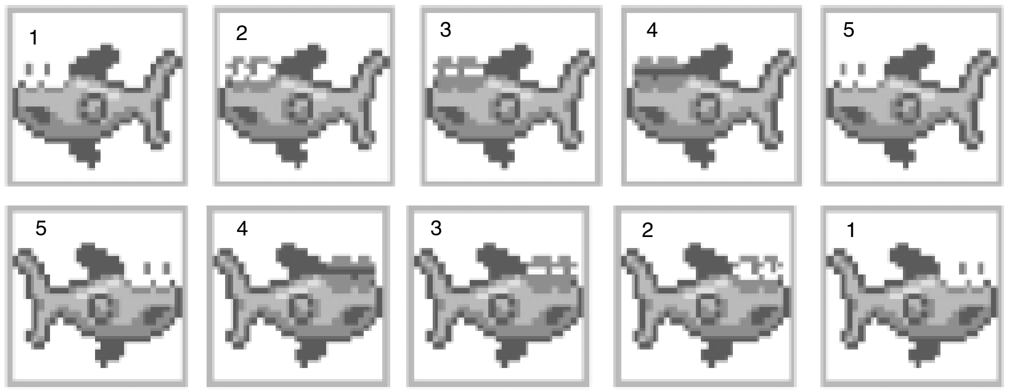


FIGURE 12-40: The Gray Shark Animation Template

Blue Angel Object Creation

TABLE 12-22: The Blue Angel Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark blue	206	0 51 153	The primary object bounding and detailing color
Medium blue	198	0 102 255	The base body color
Light blue	192	0 153 255	The foundation body color
Sky blue	150	51 204 255	The body highlighting color
Pure white	255	255 255 255	The eyeball color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

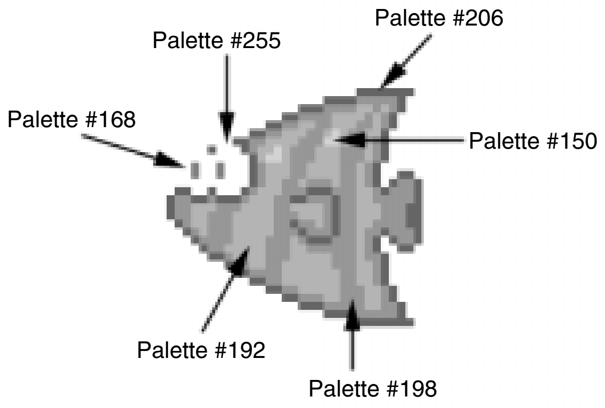


FIGURE 12-41: The Blue Angel Visual Color Map

The Blue Angel Design Template

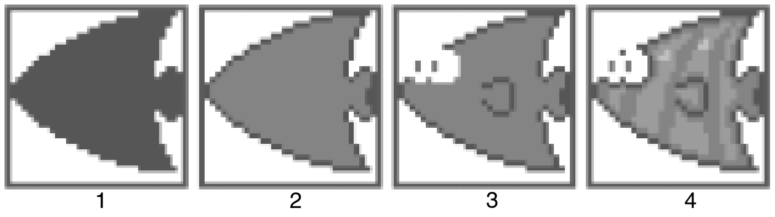


FIGURE 12-42: The Blue Angel Design Template

The Blue Angel Animation Template

Figure 12-43 contains the complete animation sequences for the Blue Angel character. Notice that this animation consists of five frames, makes use of cycling and loops, and uses the open/close animation primitive.

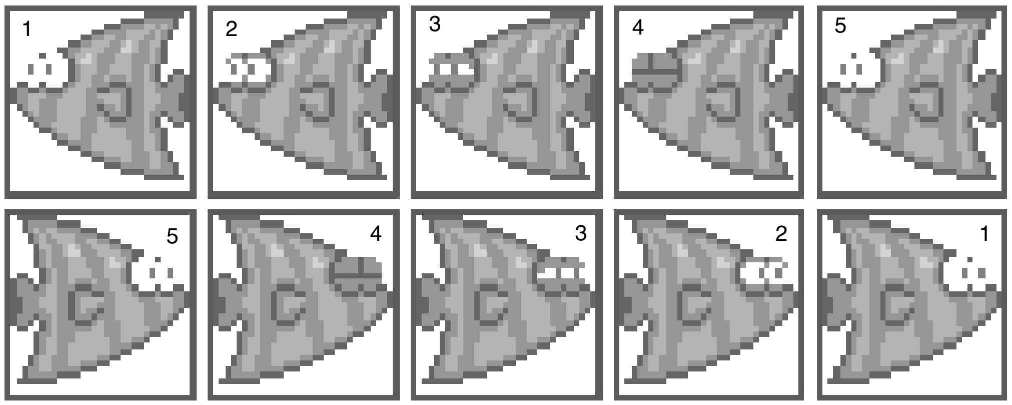


FIGURE 12-43: The Blue Angel Animation Template

Bad Tuna Object Creation

TABLE 12-23: The Bad Tuna Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark purple	140	102 0 153	The primary object bounding and detailing color
Light purple	90	153 102 255	The shadow color
Lavender	48	204 153 255	The main body color
Pure white	255	255 255 255	The eyeball and body highlighting color

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

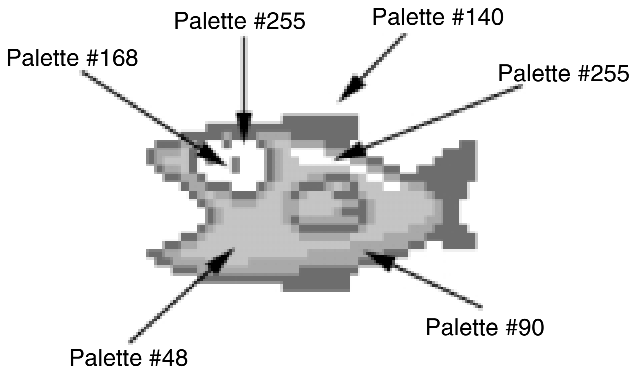


FIGURE 12-44: The Bad Tuna Visual Color Map

The Bad Tuna Design Template

Figure 12-45 shows the progressive development of the Bad Tuna object.

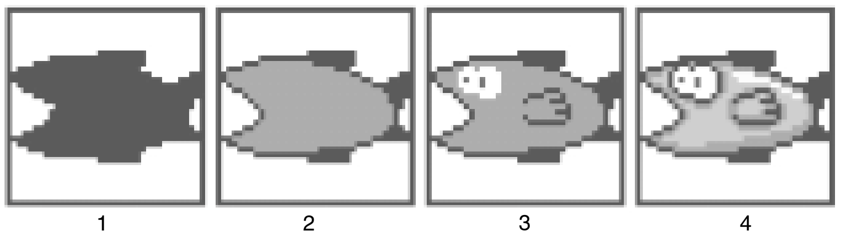


FIGURE 12-45: The Bad Tuna Design Template

The Bad Tuna Animation Template

Figure 12-46 contains the complete animation sequences for the Bad Tuna character. Notice that this animation consists of five frames, makes use of cycling and loops, and uses the open/close animation primitive.

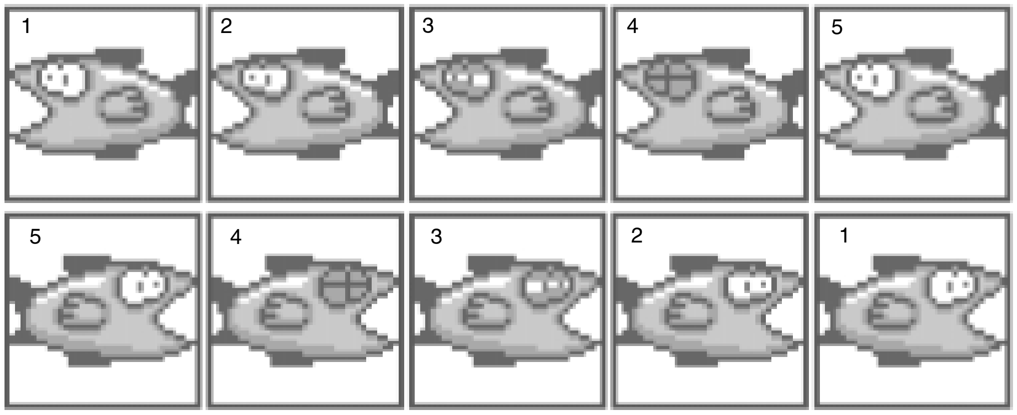


FIGURE 12-46: The Bad Tuna Animation Template

Head Hunter Object Creation

TABLE 12-24: The Head Hunter Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Light brown	59	204 102 0	The primary object bounding and detailing color
Dark tan	53	204 153 0	The shadow color
Sand	10	255 204 51	The main body color
Medium gray	86	153 153 153	The highlighting color for the teeth
Pure white	255	255 255 255	The eyeball and body highlighting color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

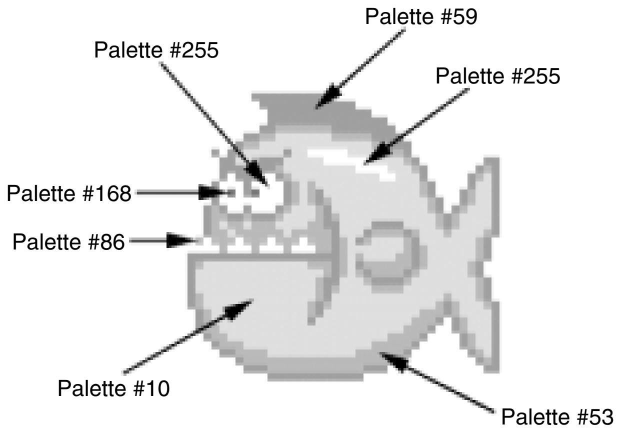


FIGURE 12-47: The Head Hunter Visual Color Map

The Head Hunter Design Template

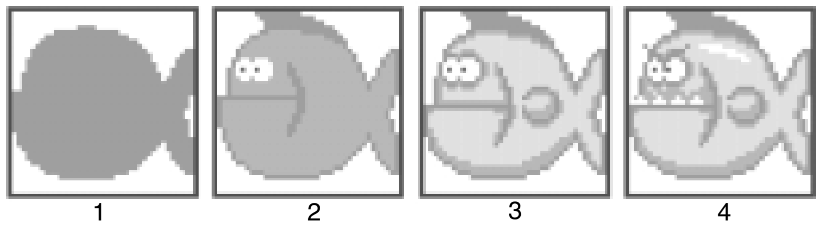


FIGURE 12-48: The Head Hunter Design Template

The Head Hunter Animation Template

Figure 12-49 contains the complete animation sequences for the Head Hunter character. Notice that this animation consists of five frames, makes use of cycling and loops, and uses the open/close animation primitive.

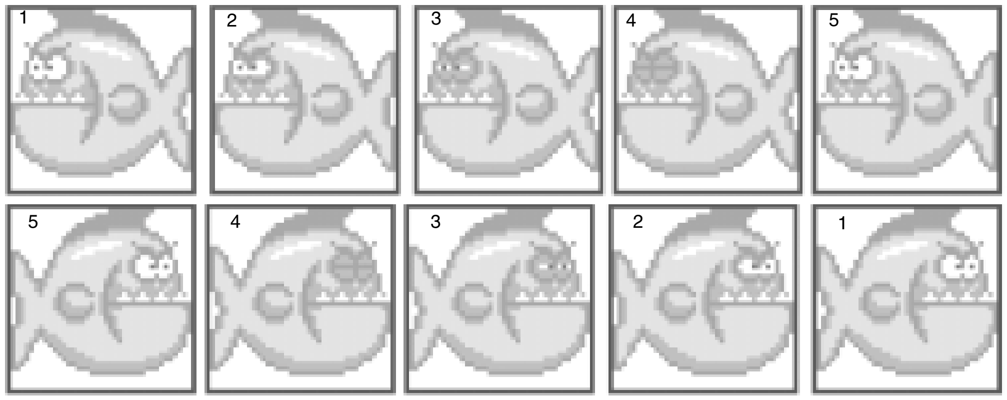


FIGURE 12-49: The Head Hunter Animation Template

Starfish Object Creation

TABLE 12-25: The Starfish Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark red	107	153 0 0	The primary object bounding and detailing color
Medium red	64	204 51 51	The shadow color
Light red	21	255 102 102	The main body color
Very light red	14	255 153 153	The highlighting color
Pure white	255	255 255 255	The eyeball color

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Light gray	43	204 204 204	The eyeball shadow color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

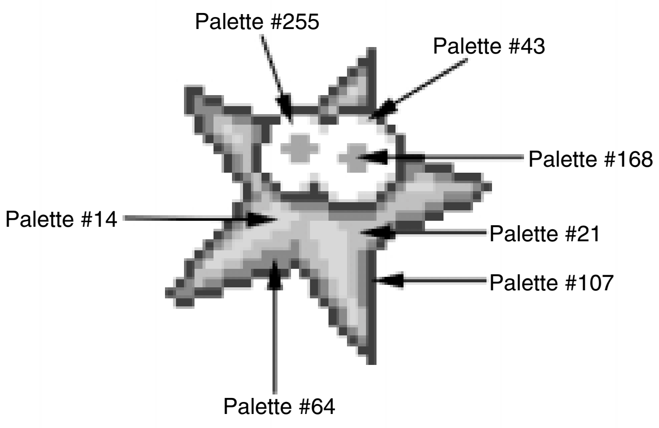


FIGURE 12-50: The Starfish Visual Color Map

The Starfish Design Template

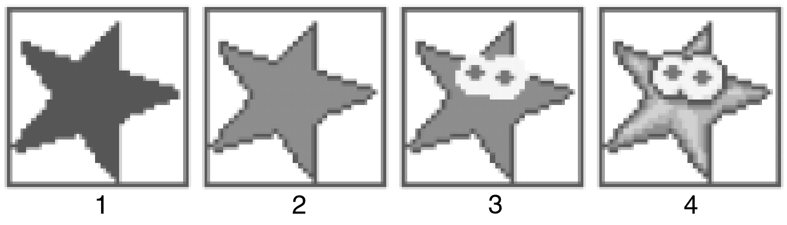


FIGURE 12-51: The Starfish Design Template

Happy Clam Object Creation

TABLE 12-26: The Happy Clam Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark brown	137	102 51 0	The primary object bounding and detailing color
Medium brown	59	204 102 0	The shadow color
Sand	17	255 153 0	The main body color

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Light gray	43	204 204 204	The eyeball shading color
Pure white	255	255 255 255	The eyeball color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.
Black	0	0 0 0	The secondary body color

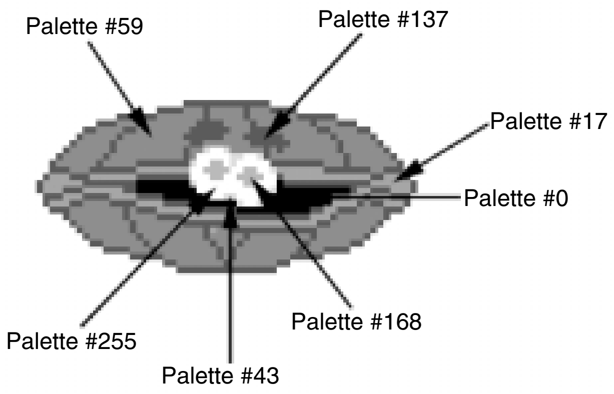


FIGURE 12-52: The Happy Clam Visual Color Map

The Happy Clam Design Template

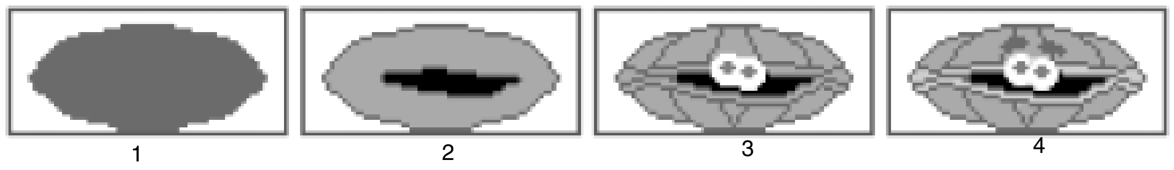


FIGURE 12-53: The Happy Clam Design Template

M.C. Hammerhead Object Creation

TABLE 12-27: The M.C. Hammerhead Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Dark gray	172	51 51 51	The primary object bounding and detailing color
Medium gray	129	102 102 102	The shadow color
Light gray	86	153 153 153	The main body color

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Pure white	255	255 255 255	The eyeball color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

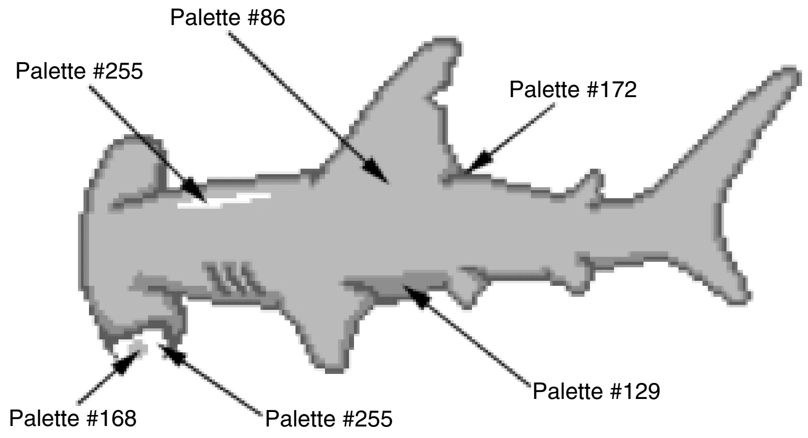


FIGURE 12-54: The M.C. Hammerhead Visual Color Map

The M.C. Hammerhead Design Template

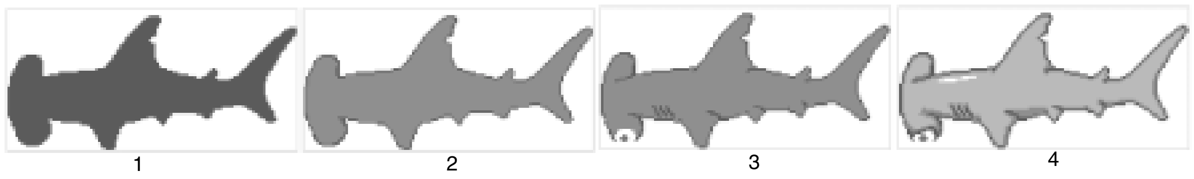


FIGURE 12-55: The M.C. Hammerhead Design Template

Salmon Fishdie Angel Object Creation

TABLE 12-28: The Salmon Fishdie Angel Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Magenta	62	204 51 153	The primary object bounding and detailing color
Medium pink	19	255 102 104	The shadow color
Hot pink	12	255 153 155	The main body color
Yellow	251	255 255 0	The halo color

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Pure white	255	255 255 255	The eyeball and wing color
Medium blue	168	51 51 255	The eye iris color. This color is standard for all game characters that appear in *Fish Dish*.

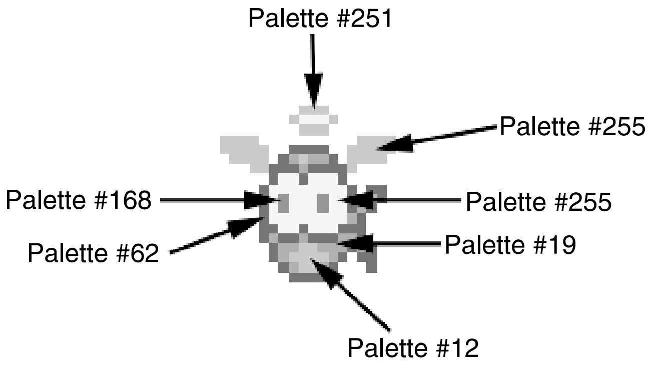


FIGURE 12-56: The Salmon Fishdie Angel Visual Color Map

The Salmon Fishdie Angel Design Template

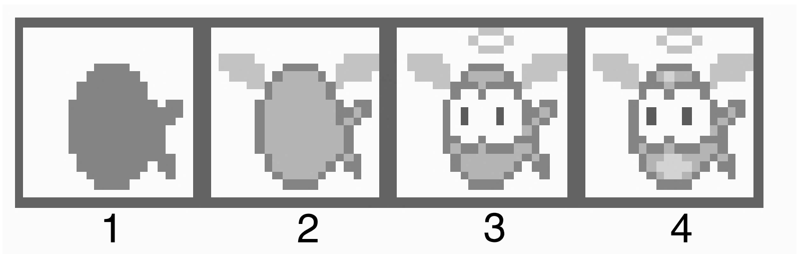


FIGURE 12-57: The Salmon Fishdie Angel Design Template

The Salmon Fishdie Angel Animation Template

Figure 12-58 contains the complete animation sequences for the Salmon Fishdie Angel character. Notice that this animation consists of three frames, makes use of cycling and loops, and uses the swing animation primitive.

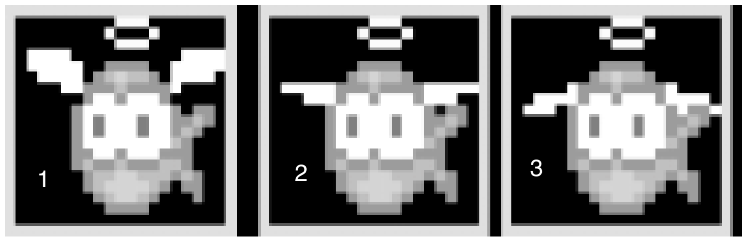


FIGURE 12-58: The Salmon Fishdie Angel Animation Template

Pause Bubble Object Creation

TABLE 12-29: The Pause Bubble Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Pure white	255	255 255 255	The bubble color
Dark gray	172	51 51 51	The stoplight color
Medium red	35	255 0 0	The first light color
Medium green	161	51 153 0	The second light color
Medium yellow	17	253 153 0	The third light color
Black	0	0 0 0	The bubble background color

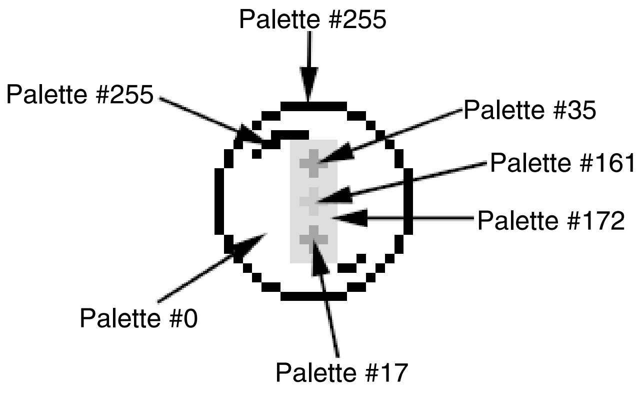


FIGURE 12-59: The Pause Bubble Visual Color Map

NOTE: The bubble outlines are white and the interiors are black as indicated by the palette numbers. However, they are shown in reverse in Figures 12-59 and 12-61.

The Pause Bubble Design Template

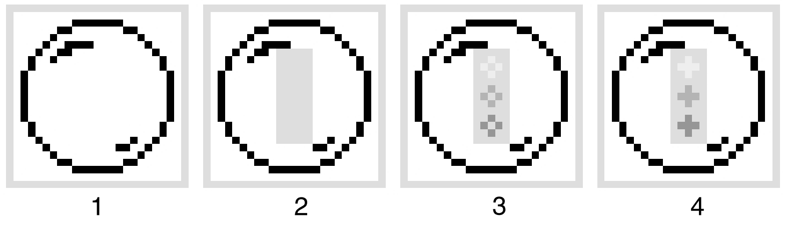


FIGURE 12-60: The Pause Bubble Design Template

Shield Bubble Object Creation

TABLE 12-30: The Shield Bubble Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Pure white	255	255 255 255	The bubble color
Light gray	43	51 51 51	The outer shield color
Medium blue	207	255 0 0	The first inner shield color
Light blue	198	51 153 0	The second inner shield color
Black	0	0 0 0	The bubble background color

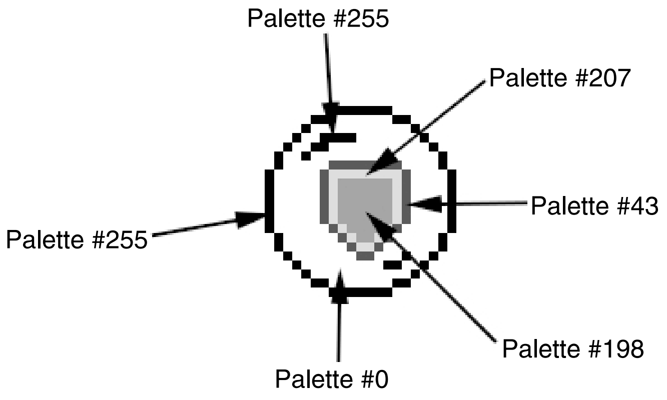


FIGURE 12-61: The Shield Bubble Visual Color Map

The Shield Bubble Design Template

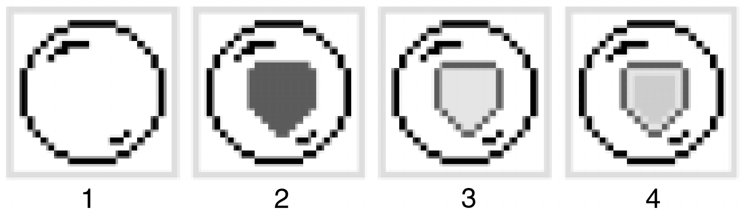


FIGURE 12-62: The Shield Bubble Design Template

Background Screen Creation

TABLE 12-31: The Background Screen Color Scheme

Generic Color Name	*Palette Entry #*	*RGB Value*	*Usage*
Medium brown	95	153 102 0	The main surface color
Dark brown	137	102 51 0	The shadow color
Beige	52	204 153 51	The highlighting color
Sky blue	114	102 204 255	The water color

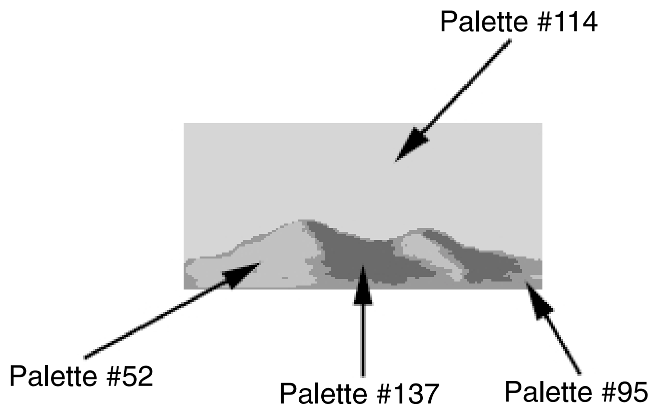


FIGURE 12-63: The Background Screen Visual Color Map

The Background Screen Design Template

Figure 12-64 shows how the seabed portion of the background was created. The simple but effective shading effect was done by using the Brush tool and Smear tool together. First, small areas of the seabed surface were painted using small brushes and then they were smeared and blended to produce the shading shown.

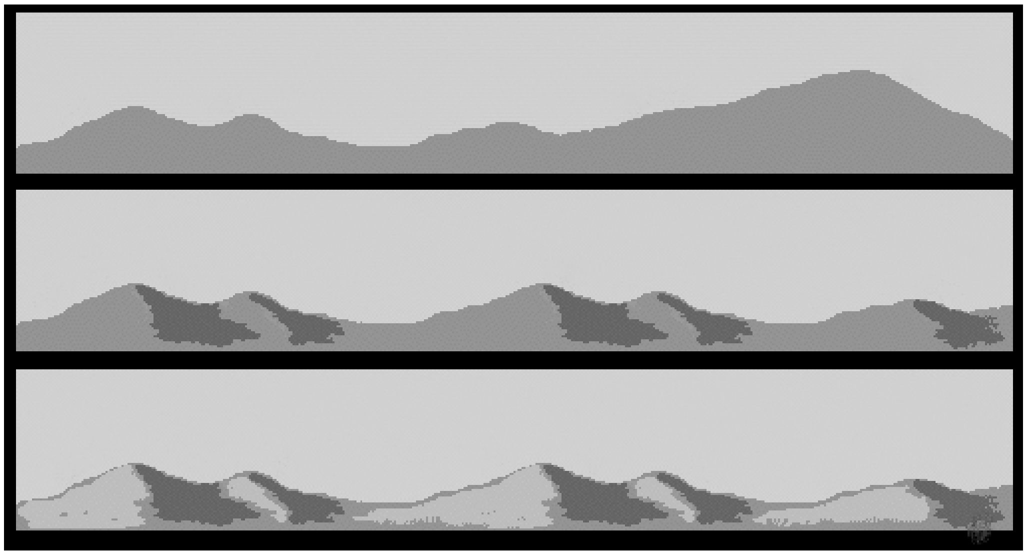


FIGURE 12-64: The Background Screen Design Template

Chapter 13

Miscellaneous Topics and Final Thoughts

In this chapter, you'll learn about:

- **Game level backgrounds**
- **Sources of inspiration**

Game Level Backgrounds

As mentioned back in Chapter 1, most types of arcade games can support multiple game levels or screens. Game levels are rendered in one of two ways: using *full-size backgrounds* and using *background tiles*.

Full-size backgrounds are just what their name implies—full-size graphic screens. Full-size backgrounds are completely self-contained images that include all of the graphical elements required to effectively represent a game level. We used a full-size background for *Fish Dish*, the game described in the previous chapter.

Background tiles are small modular graphic elements that represent a variety of different game elements. They can be arranged in a mosaic tile-like fashion to display a unique game level.

Full-size backgrounds are popular with game developers because they are relatively easy to design and integrate into a game. However, they are also notoriously inefficient. Full-size backgrounds tend to dramatically increase the overall size of the game, even with compression. The problem is compounded as the game grows in size. The more game levels, the larger the game. For example, say the average full-size background screen consumes 10 KB of space. For a five-level game this increases the size of the game by 50 K (10 x 5), which is acceptable. Yet, for a game with 100 levels, the game will increase by over 1,000 KB (10 x 100), which is not acceptable.

Background tiles, on the other hand, offer game developers a powerful alternative to the limitations imposed by full-size background screens. Because they consist of small graphic pieces, they take up far less space and memory than full-size background screens. In addition, their modularity makes them very flexible as many background tiles can be reused to represent a variety of different game levels and scenes.

Table 13-1 summarizes and compares both arcade game background techniques.

TABLE 13-1: Comparison of Full-Size Backgrounds and Background Tiles

Game Level Background Technique	*Advantages*	*Disadvantages*
Full-size backgrounds	■ Easy to design and create. ■ Easy to integrate into a game.	■ Can consume large amounts of memory and disk space making their use prohibitive for anything but small games.

Game Level Background Technique	*Advantages*	*Disadvantages*
Background tiles	■ Extremely efficient in terms of disk and memory space. Can be used to create hundreds of game levels in the same amount of space that a single full-size background might require. ■ Very flexible. Can be used to render many distinct game levels by mixing and matching individual tile elements.	■ Difficult to design. Background tiles require a high degree of precision to create. ■ Require significant design time. Background tiles need more design time in order to ensure that they are created properly.

Background tiles can trace their origin to the earliest days of arcade games and home video game systems when memory (RAM and ROM) was a precious commodity and it was simply impossible to store full-size backgrounds due to space limitations. Therefore, programmers developed an ingenious system of breaking game backgrounds into their core components, or tiles. They discovered that they could create effective background screens and levels by simply arranging these tiles in a specific way. For example, such classic arcade games as *Super Mario Land*™ and *Flying Shark*™ would not be possible without background tiles.

Since that time, background tiles have seen widespread use in arcade games, and virtually every video game console and programming tool supports their use. Background tiles are especially useful for online games and other instances where small file sizes and flexibility are of paramount importance.

Figure 13-1 shows a typical set of background tiles.

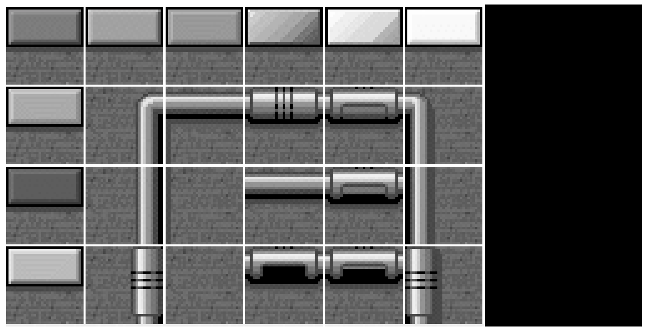


FIGURE 13-1: Arcade Game Background Tile Set

When creatively arranged, these tiles can be used to construct an almost unlimited number of game level screens like the one depicted in Figure 13-2. At the same time, background tiles make this possible while using much less memory and disk space than a full-size background screen.

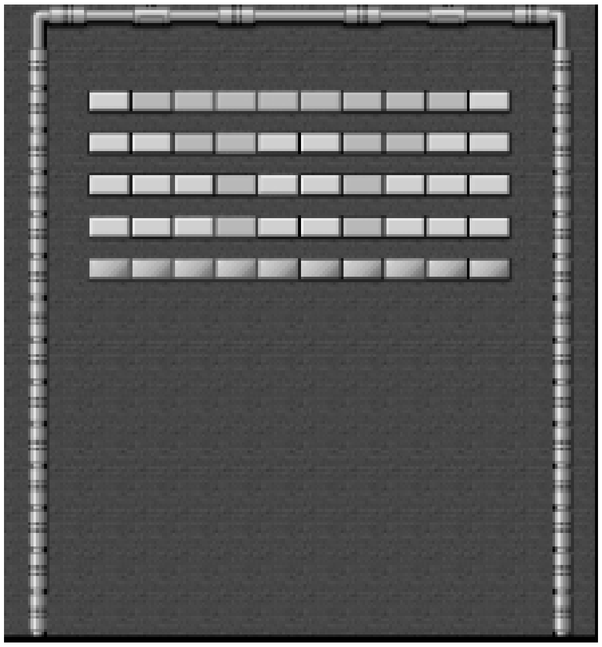


FIGURE 13-2: Example of Background Tile Arrangement

Background tiles are created using many of the same techniques that one uses to create sprites. In most cases, you can even use the same grid squares. Unfortunately, creating background tiles is not an easy process. Extreme care must be taken when designing them since each tile element must fit together perfectly with its neighbors. This can be difficult to do and can increase the design time required for any game that uses them quite substantially. Still, considering the flexibility they offer this is a relatively small price to pay.

To ensure that your background tiles are consistent and fit together properly, use your painting program's Grid tool to plot and test each grid tile in the context of how it is to be used in your game. You may also find using a specialized program such as *Map Editor* helpful in this task. Two examples of these programs can be found on the CD-ROM included with this book.

NOTE: The best way to learn how to create effective background tiles is to study how they are created. Therefore, it is recommended that you study the background tiles supplied on the book's accompanying CD-ROM. Please refer to Appendix B for more information.

Table 13-2 shows the suitability of using these game level backgrounds in different arcade games.

TABLE 13-2: Summary of Game Level Backgrounds in Arcade Games

Arcade Game Sub-genre	*Full-size Backgrounds*	*Background Tiles*	*Comments*
Maze/chase	✓	✓	Background tiles are recommended for maze/chase games with more than five unique game levels.
Pong games		✓	Background tiles should always be used in Pong games.
Puzzlers	✓	✓	Puzzlers with more than ten unique levels should use background tiles instead of full-size background screens.
Shooters	✓	✓	Background tiles are recommended for shooter games with more than five unique game levels.
Platformers		✓	Background tiles should always be used in platformers.

It is extremely important that you understand that all of the same rules that apply to other game elements will also apply to game level backgrounds. This includes color selection, resolution limitations, and design styles.

Sources of Inspiration

Over the course of this book, we have talked a great deal about the techniques and potential problems that can occur when creating arcade game graphics. However, almost nothing has been said about sources of inspiration that you can study in order to improve your skills.

By far, the best sources of inspiration for a burgeoning arcade game artist are the classic arcade games such as *Pac-Man*™, *Galaxian*™, and the like. Studying these games is akin to an art student studying the great Renaissance masters. These games and their designers were the pioneers of an industry. Their designers faced many unknowns and developed numerous techniques for dealing with them. They developed methods for rendering character shapes and styles, as well as animating them. You can learn a great deal about every aspect of arcade game graphics by taking a long, hard look at how the "early" video game masters created the various elements in these games.

Classic arcade games should be analyzed in four major areas: *color use*, *design style*, *animation technique*, and *usability*. By studying how classic arcade games addressed these areas, you can gain extremely valuable knowledge for your own arcade game projects. In some cases, you can discover what not to do, while in others you may pick up a useful technique or two. In any case, you should ask yourself these questions:

- **Color use**—How many colors are used? What is the color palette? How effectively do they use color? How do they handle light and shadow? Are any special color effects used (i.e., color cycling, dithering)?
- **Design style**—What design style do they employ? Is this design style rendered convincingly and appropriately?
- **Animation techniques**—What animation primitives are used? How effective are the animations?
- **Usability**—Are the different game objects well differentiated? How intuitive are the menu screens? How legible are the scoring, lives, and level indicators? How readable is the on-screen text and game-related messages?

Table 13-3 provides some examples of classic arcade games to analyze and study.

TABLE 13-3: Recommended Classic Arcade Games to Study

Arcade Game Sub-genre	*Classic Arcade Game*
Maze/chase	*Tank Force™, Pac Man™, Pengo™*
Pong games	Arkanoid
Puzzlers	*Tetris™, Klax™*
Shooters	*R-Type™, Raiden™, Robotron 2084™*
Platformers	*Sonic the Hedgehog™, Super Mario Land™, Megaman™, Burgertime™*

Until recently, many classic arcade games were not commonly available. However, today's powerful personal computers have spurred a generation of arcade game emulators. These emulators make it possible to run long-forgotten but classic arcade games. For the best in arcade game emulation, check out *MAME* at `http://www.mame.org`. *MAME* is available for virtually every computer platform including DOS, Windows, the Macintosh, and Linux systems.

While you're at it, you should also look at classic PC-based arcade games, as their designers also had to contend with many limitations over the years. A good source for locating these games is Moby Games at `http://www.mobygames.com`.

Final Comments

Don't consider this part of the book the end, but rather the beginning. The past 12 chapters have introduced you to the wonderful world of arcade game graphics. You have learned how to design for different display modes, how to use and apply color, how to evaluate tools, how animation works, and how to design the artwork and animation for an actual arcade game. Yet despite this, this book only scratched the surface of the topic. There is still much for you to learn and you can only learn by doing. Hopefully, this book will be successful enough to justify future editions that will expand and elaborate on the topics and concepts discussed here. Finally, before leaving, please consider this simple but practical advice:

- Practice constantly, as this is the only way to gain experience and sharpen your skills. Remember the adage, Practice makes perfect.
- Be patient! It takes time to develop and refine your skills.
- Don't be afraid to experiment with the techniques discussed in the book and in other sources.
- Don't be afraid to borrow elements (i.e., colors, style, poses, etc.) from the work of others but never steal someone else's artwork. Copying may be the highest form of flattery, but passing off someone else's designs as your own is just plain theft.
- Don't be afraid to innovate or to develop your own style and techniques. Doing this will make your work stand out and become uniquely yours.

With that being said, I wish you good luck in your future arcade game endeavors!

Ari Feldman, 2000

Index

ZapSpot Wants You!

You haven't seen sunlight in three days . . . your body can no longer maintain homeostasis . . . you wake up and try to pass parameters to your alarm clock . . . you're not having fun. Fun??? In computer science???

Yes, FUN! ZapSpot is building a top-notch software development team to bring entertainment to the masses. Think of it—we'll pay you to brighten someone's day! You still have time to get in on the ground floor of a startup.

Our three founders put in more than 20 combined years at Microsoft before the DOF (Department of Fun) sued them for having Too Much Fun and split them off. Now we want to give you the opportunity to make decisions that will affect the future of our company. Sound crazy??? No. Fun!

So, if you know C++ really, really well and you are interested in checking out New York City's fabled Silicon Alley, we'll be eagerly awaiting your resume at `jobs@zapspot.com`.

For more information on ZapSpot and the games we create, check us out at `http://www.zapspot.com`.

ZapSpot™
...life is good™

About the CD

The CD-ROM that accompanies this book contains a selection of shareware, freeware, and commercial programs and examples to help you design your own arcade game projects. These are arranged in the following directories:

- Examples—Sample arcade game graphics and backgrounds
- Fonts—TrueType fonts
- Fun—ZapSpot games
- Gamedev—Tools and libraries for creating arcade games
- Gamma—Files for determining and setting your system gamma level
- Gfxtools—Graphics tools
- Grids—Predefined sprite grid templates
- Misc—File management utilities
- Palettes—Sample color palettes

For more information about the contents of these directories, see Appendix B.

A shareware evaluation copy of WinZip is provided for extracting the contents of the archives.

You can copy the files to your hard drive (be sure to turn the read-only flag off) or use them from the CD.

NOTE: Opening the CD package makes this book nonreturnable.

Appendix B

CD-ROM Contents

In addition to containing some very useful information, this book comes with a CD packed with great programs and examples that will serve you well on your own arcade game projects.

This CD contains over 128 MB of software and graphic examples organized into the following categories:

- **EXAMPLES**—A variety of sample arcade game graphics and backgrounds to study, edit, and use freely in your own arcade game projects.
- **FONTS**—A large selection of high-quality TrueType fonts to use in your games.
- **FUN**—Play these complimentary games when you need to take a break.
- **GAMEDEV**—A nice selection of tools and libraries that can be used to make arcade games.
- **GAMMA**—Files to help you determine and set your gamma level.
- **GFXTOOLS**—A comprehensive selection of the best low-cost and free graphics tools available anywhere.
- **GRIDS**—Several predefined sprite grid templates to use for your arcade game projects.
- **MISC**—Several utilities that will help you manage your files.
- **PALETTES**—A selection of sample color palettes to use and experiment with in your own game projects.

NOTE: Several of the programs included on this CD are shareware and commercial programs. If you find any of them useful, you are encouraged to register for them or buy them.

Individual Directory Contents

This section briefly describes the contents of each directory.

EXAMPLES

- **ARINOID**—The complete graphic images for *Arinoid*, a sophisticated Pong-style arcade game.
- **COMPLEX**—A set of sophisticated frame-by-frame animation templates that can be used in your own game projects.
- **FISHDISH**—The complete graphic images for *Fish Dish*, the hands-on arcade game project described in Chapter 12.
- **MAZECHASE**—Contains images suitable for use in an infinite variety of maze/chase games.
- **PLATFORM**—Contains images useful for creating all sorts of platform games.
- **SHOOTER**—Contains images that can be used for any number of shooter games.

NOTE: There is enough variety in the provided artwork to keep one occupied for quite some time, and that's not counting the fact that many can be mixed and matched to form entirely new sprite sets.

NOTE: All of the images contained in this directory are free to use in your own games as long as you include this phrase somewhere in the program or documentation: "portions of this artwork are copyright 2000 by Ari Feldman."

FONTS

There are two directories here—one for Windows and one for DOS. The Windows directory contains the following:

- **ARMY**—Fonts useful for military-style arcade games.
- **CARTOON**—Fonts useful for arcade games with cartoon-like design styles.
- **DISPLAY**—Fonts optimized for displaying large amounts of textual information.
- **FANTASY**—A variety of fantasy-oriented fonts.
- **MISC**—Several decorative fonts.
- **SCIFI**—A variety of science fiction-oriented fonts.
- **SYMBOLS**—Several symbolic font sets.

- **TITLE**—Fonts suitable for title screens.
- **VIDGAME**—Fonts modeled after video games.
- **WORLD**—Several international style fonts.

The DOS directory contains a file called npfnts01.zip, which contains an assortment of GEM fonts compatible with *NeoPaint for DOS*.

NOTE: Most of the fonts included in this directory are free, but some are shareware. Please refer to each file for information on copyrights and any restrictions on their use.

FUN

- BullyFrog.exe—A great example of an arcade puzzler game.
- disasteroids.zip—A great example of an arcade shooter.
- FenceOut.exe—A great example of a maze/chase game.

GAMEDEV

TABLE B-1: DEVTOOL Directory

Filename	*DOS*	*Windows*	*Description*
all3932.zip	✓		The *Allegro* graphics library. A free programming library oriented to developing DOS-based arcade games.
fgl404a.zip	✓		*FastGraph for DOS* (part A). A graphics programming library useful for making DOS-based arcade games.
fgl404b.zip	✓		*FastGraph for DOS* (part B). A graphics programming library useful for making DOS-based arcade games.
as30.exe		✓	*AniSprite*. A graphics programming library useful for making Windows-based arcade games.
DXC.zip		✓	*DX-Creator*. A game-oriented development environment.
fglw600.zip		✓	*FastGraph for Windows*. A graphics programming library useful for making Windows-based arcade games.
fgw60doc.zip		✓	The documentation for *FastGraph for Windows*.
GFShw16.exe		✓	*The Games Factory*. A visually oriented game creation tool (16-bit version).
GFShw32.exe		✓	*The Games Factory*. A visually oriented game creation tool (32-bit version).

TABLE B-2: SPRITE Directory

Filename	*DOS*	*Windows*	*Description*
autograb.zip	✓	✓	*Autograb*. A utility to automatically grab batches of sprites from an image.
isd31.zip	✓		*Icons & Sprites Designer*. A sprite and icon editor.
Ixe130.zip	✓		*IXE*. A sprite precompiler.
scat160.zip	✓		*SCAT*. A utility to cut sprites from images.
sprget11a.zip	✓		*SPRiteGET*. Another utility for extracting sprites from images.
!sprite.exe		✓	*Sprite*. A sprite animation utility.
dpdl_tas.zip		✓	*The Tiny Animation Studio*. A sprite animation utility.
spredit.zip		✓	*SpriteEditor*. A sprite animation utility.
tileit_v1.zip		✓	*Tile It*. A utility for cutting images into smaller pieces.
Wspr32.zip		✓	*WSPR32*. A sprite animation utility that supports Java.

TABLE B-3: TILEEDIT Directory

Filename	*DOS*	*Windows*	*Description*
MapMaker.zip		✓	*MapMaker*. A utility for plotting background tile layouts.
mm51demo.zip		✓	*Mapmaker*. A utility for plotting background tile layouts.

GAMMA

- findgamma.gif—Use this image to determine your current gamma level.
- setgamma.gif—Use this image to help adjust your gamma level.

GFXTOOLS

TABLE B-4: ASSETMGR Directory

Filename	*DOS*	*Windows*	*Description*
Portfolio411US.exe		✓	*Extensis Portfolio*. An asset management program.

TABLE B-5: CAPTURE Directory

Filename	*DOS*	*Windows*	*Description*
St204f.zip	✓		*Screen Thief*. A screen capture utility.
Ezepro45.exe		✓	*EZ Capture Pro*. A screen capture utility.
HySnapP.exe		✓	*HyperSnap DX*. A screen capture utility.
snagt436.zip		✓	*SnagIt*. A screen capture utility.

TABLE B-6: FONTUTIL Directory

Filename	*DOS*	*Windows*	*Description*
vgafed30.zip	✓		*FONT EDITOR*. A font editor for ROM fonts.
crossfnt.zip		✓	*CrossFont*. Converts TrueType fonts between the Macintosh and PC platforms.
fgfedit.zip		✓	*FastGraph Font Editor*. A font editor for FastGraph programming library.
font2bmp.zip		✓	*Font2bmp*. A utility that converts TrueType fonts into .BMP files.
ttgem.zip		✓	*TT2Gem*. A utility that converts TrueType fonts into GEM fonts.

TABLE B-7: MISC Directory

Filename	*DOS*	*Windows*	*Description*
MkExpl.zip	✓		*MkExpl*. A utility that generates explosion effects.
pcxred.zip	✓		Mercury PCX Reducer. A utility for scaling .PCX files.
squash10.zip	✓		*WSQUASH*. A specialized file compression utility for .BMP files.
Apr.zip		✓	*PicturesToExe*. Converts one or more graphic files into standalone EXE files.
univ162.zip		✓	*Universe*. A utility that allows you to visually compose space-oriented artwork.

TABLE B-8: PAINT Directory

Filename	*DOS*	*Windows*	*Description*
dnpaint.zip	✓		*DN Paint*. A DOS-based painting program.
gfx2b965.zip	✓		*GrafX2*. A DOS-based painting program.
improc42.zip	✓		*Improces*. A DOS-based painting and image processing program.

Filename	*DOS*	*Windows*	*Description*
npt.zip	✓		*NeoPaint for DOS*. A DOS-based painting program.
px32e96.zip	✓		*Pixel 32*. A DOS-based painting and image processing program.
vp386exe.zip	✓		*VGA Paint 386*. A DOS-based painting program.
artgem.zip		✓	*ArtGem*. A Windows-based painting program.
chaosfx12.exe		✓	*Chaos FX*. A Windows-based painting and image processing program.
npw.zip		✓	*NeoPaint for Windows*. A Windows-based painting program.
pm42fd.zip		✓	*Pro Motion*. A Windows-based painting program.
pm42lt.zip		✓	*Pro Motion Lite*. A Windows-based painting program.
psp602ev.exe		✓	*Paint Shop Pro*. A Windows-based painting and image processing program.
pxw997e.zip		✓	*Pixel 32*. A Windows-based painting and image processing program.
up24.zip		✓	*Ultimate Paint*. A Windows-based painting program.

TABLE B-9: PALTOOLS Directory

Filename	*DOS*	*Windows*	*Description*
epal11.zip	✓		*EditPal*. A palette editor.
fixp28a.zip	✓		*Fix Pal*. A utility to apply a universal color palette to a group of images.
neopal.zip	✓		*NeoPal*. A utility that creates *NeoPaint for DOS* color palettes from images.
unipal.zip	✓		*UniPal*. A utility to apply a universal color palette to a group of images.
palmer30.exe		✓	*PalMerge*. A full-featured palette editor.
SetupOPal.exe		✓	*Opal*. A full-featured palette editor.
WhatColour.zip		✓	*What Colour*. A utility that tells you the RGB values for any color on the screen.

TABLE B-10: SCRUTIL Directory

Filename	*DOS*	*Windows*	*Description*
tweak16b.zip	✓		*Tweak*. A utility that allows you to construct your own Mode X video modes.

Filename	*DOS*	*Windows*	*Description*
unirfrsh.zip	✓		*UniRefresh*. A utility that allows you to set the refresh rate for any DOS-compatible display mode.
hztool14.zip		✓	*Hz Tool*. A utility that allows you to set the refresh rate for any Windows-compatible display mode.
vidres.zip		✓	*VidRes*. A utility that allows you to select any display mode supported by your video hardware.
zoomts21.zip		✓	*ZoomTools*. This program contains a graphic capture, magnifier, microscope, ruler, tape, square, and color analyzer.

TABLE B-11: VIEWER Directory

Filename	*DOS*	*Windows*	*Description*
Disp.exe	✓		*Display.* An image viewer and file conversion utility.
vwi86.zip	✓		*Nview.* An image viewer and file conversion utility.
cpic32.exe		✓	*CompuPic 32*. An image viewer and file conversion utility.
gwsp20.exe		✓	*Graphics Workshop Pro*. An image viewer and file conversion utility.
iview321.zip		✓	*IrfanView 32*. An image viewer and file conversion utility.
Xnview-gb-win.zip		✓	*XNView*. An image viewer and file conversion utility.

GRIDS

- 128x128.bmp—A 128x128 sprite or background tile template.
- 16x16.bmp—A 16x16 sprite or background tile template.
- 24x24.bmp—A 24x24 sprite or background tile template.
- 32x32.bmp—A 32x32 sprite or background tile template.
- 36x36.bmp—A 36x36 sprite or background tile template.
- 40x40.bmp—A 40x40 sprite or background tile template.
- 48x48.bmp—A 48x48 sprite or background tile template.
- 64x128.bmp—A 64x128 sprite or background tile template.
- 64x64.bmp—A 64x64 sprite or background tile template.
- 64x96.bmp—A 64x96 sprite or background tile template.
- 96x96.bmp—A 96x96 sprite or background tile template.

MISC

TABLE B-12: BACKUP Directory

Filename	*DOS*	*Windows*	*Description*
FileBack.zip		✓	*FileBackPC*. A full-featured file backup utility.

TABLE B-13: CHARTING Directory

Filename	*DOS*	*Windows*	*Description*
wftrial.exe		✓	*WizFlow*. A flowcharting and diagramming utility.

TABLE B-14: FILEEXCH Directory

Filename	*DOS*	*Windows*	*Description*
Macsee.zip	✓		*MacSee*. A utility that allows DOS users to read files from Macintosh disk media.
tmac.zip		✓	*TransMac*. A utility that allows Windows users to read files from Macintosh disk media.

TABLE B-15 VERCTRL Directory

Filename	*DOS*	*Windows*	*Description*
cs-rcs.zip		✓	*ComponentSoftware RCS*. A version control utility.

PALETTES

- dos_sample1.pal—Sample DOS palette.
- dos_sample2.pal—Sample DOS palette.
- dos16.pal—DOS 16-color system palette.
- dos256.pal—DOS 256-color system palette.
- mac256.pal—The Macintosh 256-color system palette.
- netscape216.pal—The Java/Netscape 216-color system palette.
- starter_palettes.html—A collection of 50 sample color gradient examples.
- win_sample1.pal—Sample Windows palette.
- win_sample2.pal—Sample Windows palette.
- win_sample3.pal—Sample Windows palette.
- win_sample4.pal—Sample Windows palette.
- win256.pal—The Windows 256-color system palette.

Appendix A

Artist Interviews

I feel that this book wouldn't be complete without getting other computer artists' perspectives on game art and computer graphics design in general.

For this section, I've been fortunate to speak to two very talented individuals. I asked each artist a series of questions divided into three parts: *personal*, *design*, and *technical*. The personal questions probe into the artist's background and experience in game and computer artwork. The design-oriented questions examine the artist's feelings and approach towards arcade game graphics design and 2D-computer artwork in general. The technical questions explore the artist's opinions on different software and tools.

Karl Maritaud (nickname: X-Man)

The first person I interviewed was Karl Maritaud. Karl is a part-time demo *graphician*, or graphic artist, who specializes in creating artwork for the PC demo scene in France. He has also dabbled quite a bit in computer game graphics design, and is an extremely talented artist as shown by Figures A-1 and A-2.

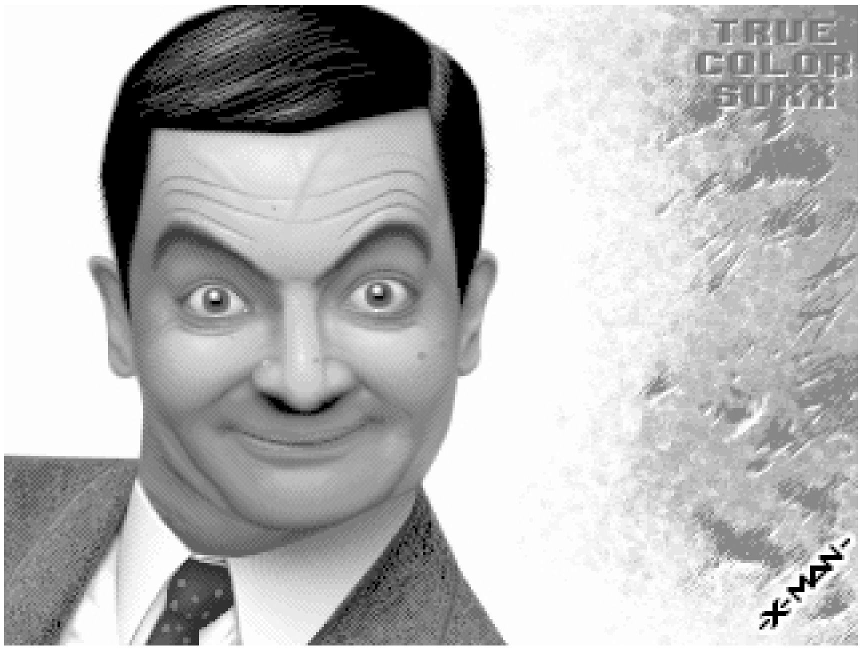


FIGURE A-1: Example of Karl's Artistic Ability (and done with less than 256 colors!)

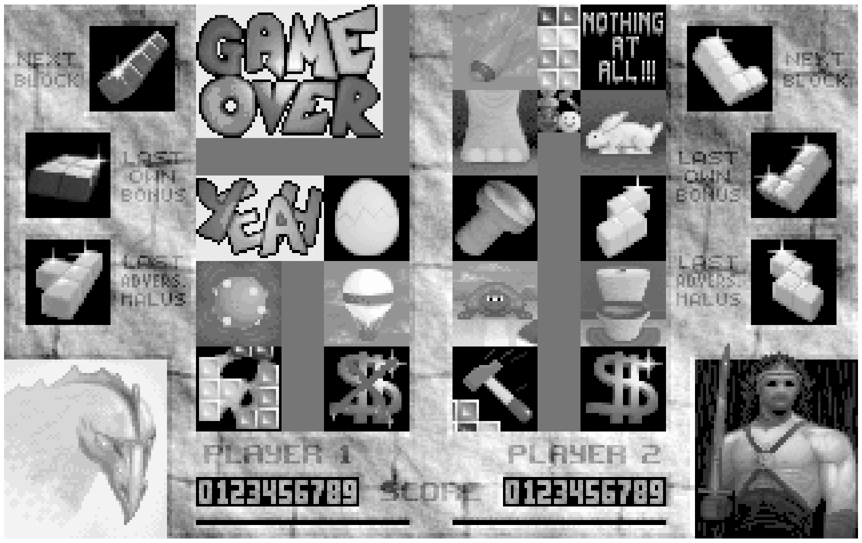


FIGURE A-2: Example of Karl's Game Artwork

Personal Questions

1. **What is your background and how did you get started in computer artwork?**

   I'm currently a computer scientist who is doing a Ph.D. thesis in image synthesis. So, you can see that my passion for pixels has influenced my studies. This interest in computer graphics started when I got my first paint program on my first computer. It was *The OCP Art Studio* on an Amstrad CPC 6128.

2. **How long have you been creating computer artwork?**

   Since the day mentioned above. I've been doing it for about 11 or 12 years now. But it became "serious" when I got involved in the "demo scene" five years ago.

3. **Do you think 2D artwork is dead or does it have a future given the interest in 3D graphics?**

   Well, it's true that 3D has invaded the computer graphics domain. But 2D skills are still needed to draw textures and retouch rendered scenes, etc. Anyway, even if 2D artwork really died, I'd continue to draw in 2D, because I like it! I don't live from my pictures; it's just for my pleasure, so I don't really care about what is the standard in game companies.

   All I can say is that I loooooove the low-res 2D landscapes in the game *Simon the Sorcerer*, and I really cannot imagine them in 3D.

4. **What's your favorite platform for creating computer artwork—Mac, PC, Amiga, Falcon, etc.?**

   The PC, definitely.

Design Questions

1. **How do you approach a project? Is there a certain procedure you follow? Do you just start drawing or do you take the time to plan your artwork out?**

   It's really variable. For some pictures, I know exactly what I want to draw before starting (especially when I just want to copy from a model). Sometimes, I start from a model but then I decide to add things that I didn't think of in the beginning. And sometimes, I make a whole picture without knowing what it will exactly look like at the end; just from an idea that become clearer or can totally change while I'm drawing. It's like writing a book. You've got the main idea that makes you start to write, and then your imagination finds ways to link and enhance these ideas.

2. **What inspires you creatively?**

   Everything. Photography, sci-fi, heroic fantasy, movies… But anyway, I've got to be more creative. In the "demo scene," we use the label "no copy" when a picture was built from imagination. I mostly used to draw copies or half-copies, but now I want to be able to stamp the "no copy" label on my pictures.

3. **What's your favorite type of computer artwork? Do you like doing stills for demos better or do you prefer doing game-oriented artwork?**

   Well, I've done graphics for a few little non-commercial games and I've also worked on a bigger project that was unfortunately aborted. It was interesting, but I prefer drawing for my pleasure, because I don't have to fear whether the result will be good or bad. When I am more confident in my skills, maybe I'll start to enjoy drawing for commercial projects.

4. **What's the best way to develop your overall artistic techniques?**

   Looking at others' work! One has much to learn from others. It's very interesting to try to figure out how your favorite computer graphics artists draw. By trying to do like someone else, you can find new techniques, even different from the one you originally tried to copy. Another very interesting way is to read tutorials from others. There are plenty of them on the Web.

5. **How do you approach different types of artwork? In other words, how would you approach doing a demo screen versus sprite artwork for a game, etc.?**

   The only difference for me is freedom. For a demo screen, the only restraints are your imagination and your talent (and the competition rules, but they are not very restrictive, except for "old-school" competitions). But for a game, you have to respect its overall mood. But the techniques, for me, are about the same. I have something to draw, so I draw it. Actually, I'm quite attached to details, so a picture is kind of a huge set of sprites that must all be drawn with precision.

6. **What's the most difficult part of designing game graphics?**

   From my experience in this domain, I'd say that the most difficult thing is to define the global aspect of the game, and to keep close to it. The best is when you can hardly tell who drew what. You know, when several artists work on a game, they must try to adapt their style to others' and that is not easy.

Technical Questions

1. **What are your favorite painting tools/image editors for 8-bit artwork and why? What's your favorite true color image editor and why?**

   For 8-bit drawing, my favorite program is *GrafX2*. Why? Well… because I'm one of its two creators! But more seriously, because it does almost all that I want for 8-bit artwork. And what has not been done yet will be, if we find time and motivation. Another reason is simply because there are not many good 8-bit paint programs on PC, and then I objectively think that *GrafX2* is one of the best, if not the best. It's really user friendly once you become familiar to the keyboard shortcuts.

For true color, my favorite one is *Photoshop 5*. The word "photo" in its name does not mean that you can't draw with. It's really powerful and I seldom use more than 10% of its power. There are many other programs for true color painting, but *Photoshop* does all that I want, and it does it well.

2. **What are the most important features for a drawing tool to have and why?**

   Well, it really depends if it is for 8-bit or true color drawing. For 8-bit, a good program requires, in my opinion, the following features: the basic tools: free-hand drawing, lines, polygons, rectangles, circles, flood-fill, etc.; the basic effects: shade (change to the next color in a color range), smooth (blur), colorize, etc., and the possibility to control which colors must be used when the effect looks for the nearest color in the palette to the one it has computed; and the possibility to arrange your palette as you wish: for example, allowing the user to insert a color into a gradient without shifting the correspondence between the colors in the palette and the pixels in the image.

   For true color, I need the basic tools: the same as for 8-bit and a few others that were effects in 8-bit programs like blur and smudge; effects: darken, lighten, colorize; filters: the most basic ones and the "HSB noise" from Eye Candy; layers; and color adjustments (gamma, contrast, and color balance).

   I could do with less, but I have greatly needed all the mentioned features at least once.

3. **What other graphics tools (i.e., image viewers, converters, etc.) do you use and why?**

   Viewers: *ACDSee* for fast viewing, *SEA* for full-screen viewing true color pictures, and *GrafX2* for full-screen viewing 8-bit pictures.

   Converters: I rarely convert images, but when I do, I use either *Photoshop* or *Paint Shop Pro*.

4. **Do you have a specific file format preference (i.e., .PCX, .BMP, etc.) and why?**

   GIF for 8-bit images, and PNG or TGA for true color. These are for artwork, of course, because JPEG is good enough for the rest. But I couldn't use lossy compression for images drawn with a computer; that's out of the question.

5. **How do you go about defining your color palettes?**

   I define the main color gradients and a few others that are close to the first ones. The main gradients will be used for the main shapes of the image, and the others will "break" the main gradients because images with only one color gradient per shape are really ugly. In my opinion, a good picture requires color variations.

6. **What are some of the issues to watch out for and consider when constructing a color palette?**

   There shouldn't be any important problems if the palette editors were perfect. In most paint programs, it is not possible to move colors in the palette without destroying the picture. This is not a problem in *GrafX2* thanks to its X-swap option. This option allows the user to insert colors in a gradient, to delete unused colors without letting "holes" in the palette, etc.

   On the other hand, *GrafX2* does not offer yet all the interesting features from most true color programs where you can adjust colors, contrast, gamma correction, or simply edit them in the hue-saturation-brightness color space.

   Now, apart from the limitations of the palette editor, it is better not to use all the 256 colors in the beginning because you might need extra colors later. For example, if you had a rather pink face to draw and want to anti-alias the neck with a green pullover (just an example), you'll first define pink gradients (more than one!) and green gradients. But you'll also need a few colors between green and pink for anti-aliasing. And you can't define these colors while you haven't (more or less roughly) drawn the neck and the pullover.

7. **What is your favorite screen resolution to draw in and why?**

   In 8-bit, my favorite resolution is 320x240. It's a low resolution because pixeling requires a lot of work in order to get a good picture. And it's got square pixels.

   In true color, I don't really have a favorite resolution because you don't work on each pixel separately. But I generally draw 640x480 or 800x600 pictures. And, since most true color picture editors work in a windowed environment, I think it's interesting to speak about the chosen resolution. I personally configured Windows in 1152x864 because it's the biggest resolution supported by my monitor that offers square pixels. Indeed, 1280x1024 has an aspect ratio of 5/4 instead of the standard 4/3 for monitors.

   You can contact Karl directly via email at `maritaud@ensil.unilim.fr` or by visiting his Web site at `http://www-msi.ensil.unilim.fr/~maritaud`.

Neil Shepard (nickname: The Neil)

Neil Shepard is an experienced arcade game artist from the United Kingdom. To date, he has created the artwork and animation for over a dozen well-received arcade games. Figures A-3 and A-4 demonstrate Neil's impressive work.

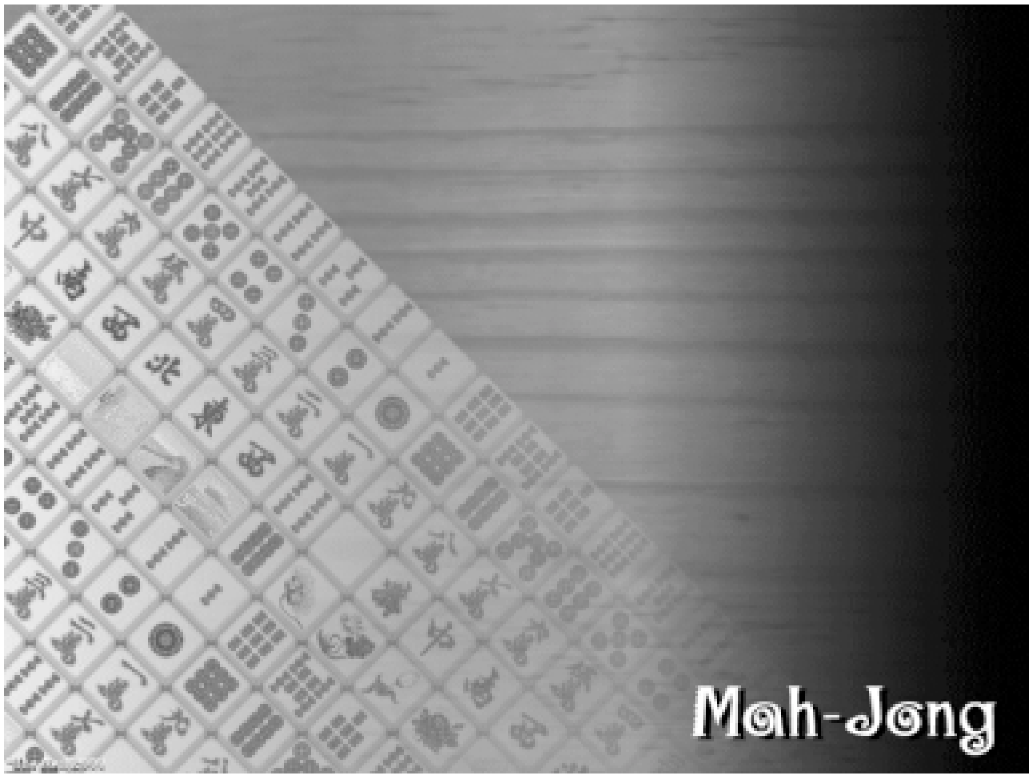


FIGURE A-3: Example of Neil's Title Screen Artwork

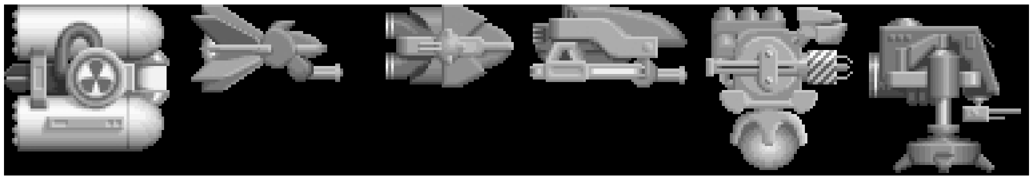


FIGURE A-4: Example of Neil's Game Sprites

Personal Questions

1. **What is your background and how did you get started in computer artwork?**

   I'm a 25-year-old UK software developer by profession and I develop game graphics as part of the DP team outside of work. I got hooked up with my partner (in a game sense) Del Dixon while I was at a university. He was developing games and needed an artist. I'd been playing around with doing artwork (not game graphics) as a kind of hobby (I'd studied art at school and at that time home computing was just starting to allow decent artwork to be developed). He showed me what he'd done and I said I could give them an overhaul.

Apparently, I did a good job, and we've been working together on games for about five or six years now. So, now I develop graphics for the team in my spare time and work as a Delphi developer during the day. This allows me to understand hardware, pixels, color depths, etc., but I can also bring my art experience to the programming side of things.

2. **How long have you been creating computer artwork?**

   Game graphics for about five or six years and computer artwork in general for maybe six or seven. As for anything that I'd actually be prepared to release into the public domain then maybe one or two years.

3. **Do you think 2D artwork is dead or does it have a future given the interest in 3D graphics?**

   Three-dimensional graphics are great and all the rage right now but 2D graphics do have their place. Three-dimensional graphics are only really going to work when you create a 3D environment for the player to operate in. As soon as you jump to 2D environments then you're going to have to bring an element of 2D into the equation. There are also practical considerations—maybe you could create everything in *3D Studio* (for example), but actually manually drawing your graphics gives you an extra level of control.

4. **What's your favorite platform for creating computer artwork—Mac, PC, Amiga, Falcon, etc.?**

   I originally started way back in the dim distant past using a BBC B, then jumped up to the Acorn A3000. Finally, I moved over to the PC and everything I've ever done for games and release has been on the PC. Of course, if anyone wants to lose a Silicon Graphics machine in my direction, then I'm sure I could find space on my desk.

Design Questions

1. **How do you approach a project? Is there a certain procedure you follow? Do you just start drawing or do you take the time to plan your artwork out?**

   I never just jump into artwork. If you jump into drawing straight away or before the whole thing is agreed upon then you'll hit problems and end up having to do an awful lot of work. Personally I'll try to get the theme for an entire set of graphics before I start thinking about specifics. This can often dictate how the rest of the graphics are going to go (e.g., if a game requires realistic graphics, then characters like cats wearing denim jackets and giant boots are generally out). Another thing that I try to insist on is having a complete list of the graphics needed before I get started. Not only does this give you a better idea of time scale, but it's easier to work out that if sprite A is thing X then sprite B can be thing Y.

I'm very much a sketch artist. I make page after page of sketches and let ideas work their way through my head for a few days before I start creating anything on the machine. General artwork in itself is difficult but in game graphics there is the added problem of making graphics that have to be modular (e.g., pipes), functional (e.g., lifts, ladders), etc. Certain game styles really do create nightmares—isometric games, games where there is an element of sprites being overlaid, etc.

2. **What inspires you creatively?**

   Life! It might sound a bit glib but we do live a world full of ideas. Personally I'm a sci-fi and film fan so I simply take all that I see and use bits and pieces all over the place. It sometimes takes one thought to lead to another, sometimes it can take days of getting nothing and then suddenly get inspired by the most unlikely things.

3. **What's your favorite type of computer artwork? Do you like doing stills for demos better or do you prefer doing game-oriented artwork?**

   Each brings its own rewards. Game graphics really give me a buzz when it all comes together and the various aspects all fit in, but on the other hand static screen artwork looks fabulous and when done properly can have such impact. If push came to shove then I would have to go for static artwork (even though I do create 90% of mine in *3D Studio*).

4. **What's the best way to develop your overall artistic techniques?**

   Practice, study other people's work, and keep things simple. I don't mean rip their work off, but see how they light things, how they shade things—Do sprites look better with a black/dark surround? Do they look better anti-aliased? etc. In the field of animation then, watch how real people/things move and try to incorporate that into your animations. They'll look more realistic and natural if you do.

5. **How do you approach different types of artwork? In other words, how would you approach doing a demo screen versus sprite artwork for a game, etc.?**

   Designing a sprite means a lot more work basically. I tend to think about how the sprite is going to move, how it's going to interact with other graphics, etc. A screen, on the other hand, is totally static (obviously) but you can make it far more dramatic, light it more stylistically, etc.

6. **What's the most difficult part of designing game graphics?**

   For actual type of graphics it would have to be animation, closely followed by modular graphics. The biggest pain, however, is coming up with an idea and then being able to apply that idea to all of the various elements. This can often be very difficult.

7. **Do you have any pointers or tips on creating sprites and backgrounds for games?**

   As with everything it all depends on what you're trying to create but there are several things that I always keep in mind:

   The graphics are what generally sell your game to the user (game play is important but the graphics are what are going to grab people's attention in the first place) so make them bright, colorful, and eye-catching.

   Keep things simple to start with when it comes to sprites and animation—you can always add extra bits and pieces later.

   When it comes to backdrops, try to tone them down; otherwise, they'll overpower the foreground graphics and it'll be difficult to see things.

   Pick a style and stick to it throughout your game. Don't have a mixture of styles (e.g., all rotoscoped, all cute, all photo-realistic) as it'll look messy. If it all flows together then it will look slicker and more professional.

   Think about your animations—do they have to cycle? How do they get on and off the screen? (If you can make them appear and then disappear, then they'll look far better than if they just suddenly pop up, do their thing, and then vanish).

   When you're developing cartoon-style graphics, emphasize everything—make colors brighter, movements more exaggerated, etc. It'll add impact and make the whole thing look that little bit more dynamic.

   Sprite edges can be tricky. Think about what the sprite is going to be displayed on top of. If it's a generally dark background then try to anti-alias them (by hand, sadly) slightly to a dark color (they'll look far more integrated if you do).

   When you animate objects, think about how they move in the real world. Don't go overboard (or get weighed down), but try to take things like gravity, inertia, etc., into consideration when you animate your object.

   Again with animation, never jump straight in and create final frames. Create a skeleton (stick) version, get that moving correctly, then add the body. Once this version is fine, you can then add the actual colors, shading, etc. If the basic movement is wrong, then you've got a lot of work ahead of you trying to fix it.

Technical Questions

1. **What are your favorite painting tools/image editors for 8-bit artwork and why? What's your favorite true color image editor and why?**

   I used to be a big fan of *Neopaint* (for DOS) but it's showing its age now and I've now switched to JASC's *Paint Shop Pro* for the majority of both 8- and 24-bit editing. *Neopaint* had the great advantage of being able to quickly access the palette but was let down by a general lack of features. *PSP* has the features but not quite as quick access to the palette. It swings and roundabouts as to which one I use but *Neopaint* is becoming too long in the tooth (and won't work under Windows NT anyway). When it comes to things like splash and About screens, though, I leave 2D land and usually go straight for *3D Studio*. Yes, it's big, a bit scary (to the novice anyway), and causes all sorts of headaches when you start thinking about meshes, objects, etc., but it speeds the development process up incredibly (and you can always touch the stuff up in *PSP* anyway).

2. **What are the most important features for a drawing tool to have and why?**

   Definitely the ability to operate on a pixel level and have the ability to switch anti-aliasing and other features off. Working with 2D graphics always means that you're going to want to work at the most primitive level (it offers the best control) and that means getting your hands dirty and playing around with pixels in some shape or form. I'm not saying that anti-aliasing, etc., have no place, as they most certainly do (especially as graphics are getting just too big to do completely manually nowadays), but for the basics of animation, they are just something to confuse the matter.

   After that, it would be the ability to be able to work directly with palettes (switching between tools and colors really quickly is nice too).

3. **What other graphics tools (i.e., image viewers, converters, etc.) do you use and why?**

   I'm also a programmer and have put together a package of my own [*Author: Tiny Animation Studio*, included on the book's accompanying CD-ROM]. Basically this does a load of the normally mundane and downright difficult tasks like merging, etc. If I find something that I can't do anywhere else (i.e., without spending cash) I just work out the steps involved and write a new function for that. Occasionally I'll go back to using Microsoft's *Paint* but usually only when I'm working out the basics of animation. It gives you quick access to the palette as well as pixel editing. As I said though, it's used only at the very start of an animation (after that it goes into *PSP*). For testing animations I use another application that I've developed myself (*Tiny Animation Studio*—TAS, available from my Web site).

4. **Do you have a specific file format preference (i.e., .PCX, .BMP, etc.) and why?**

   Personally I prefer PCX for eight bit images and BMP for 24 bit. Both are non-lossy (try saving 24-bit images in JPEG and you'll see your artwork disintegrate after a while). As to why I use them... PCX is pretty small, offers fairly good compression, and, most importantly, is easy to understand if you ever need to play around with the file in code. BMP may be large and wasteful of space but again it's very easy to use in code (I use Delphi and that has explicit support for BMP). I could use BMP for both, but by storing 8-bit as

PCX, and 24-bit as BMP, I can easily see which graphics are ready to be incorporated into a game (PCX), and which are development versions (BMP).

5. **How do you go about defining your color palettes?**

   It's not something that I do very often. I've found that over time you become accustomed to just one palette that has a good spread of colors (and any shade that's missing can be achieved by dithering). Not only does it have a good spread of colors but it also allows you to be able to jump to colors within the palette almost without thinking. Being able to do this really speeds things up. In short, go for the most comprehensive range of colors possible—it'll make life so much easier.

6. **What are some of the issues to watch out for and consider when constructing a color palette?**

   Make sure you have a good range of colors! Try to have the right number of greens, blues, reds, and, most importantly grays. As I said, you tend to come up with a standard palette that you keep going back to. It might need a little tweaking now and then, but generally it covers all possibilities.

7. **What is your favorite screen resolution to draw in and why?**

   At work I use 1024x768 but at home, 800x600. Both are at 24-bit color depth though. Anything bigger and you start to lose small sprites. It's also easier to see how they'll look on a user's machine if you use something similar to what the standard user uses.

You can contact Neil directly via email at `TheNeil@Bigfoot.com` or by visiting his Web site at `http://www.dodgyposse.home.dhs.org/dodgyposse/`.

Designing Arcade Computer Game Graphics